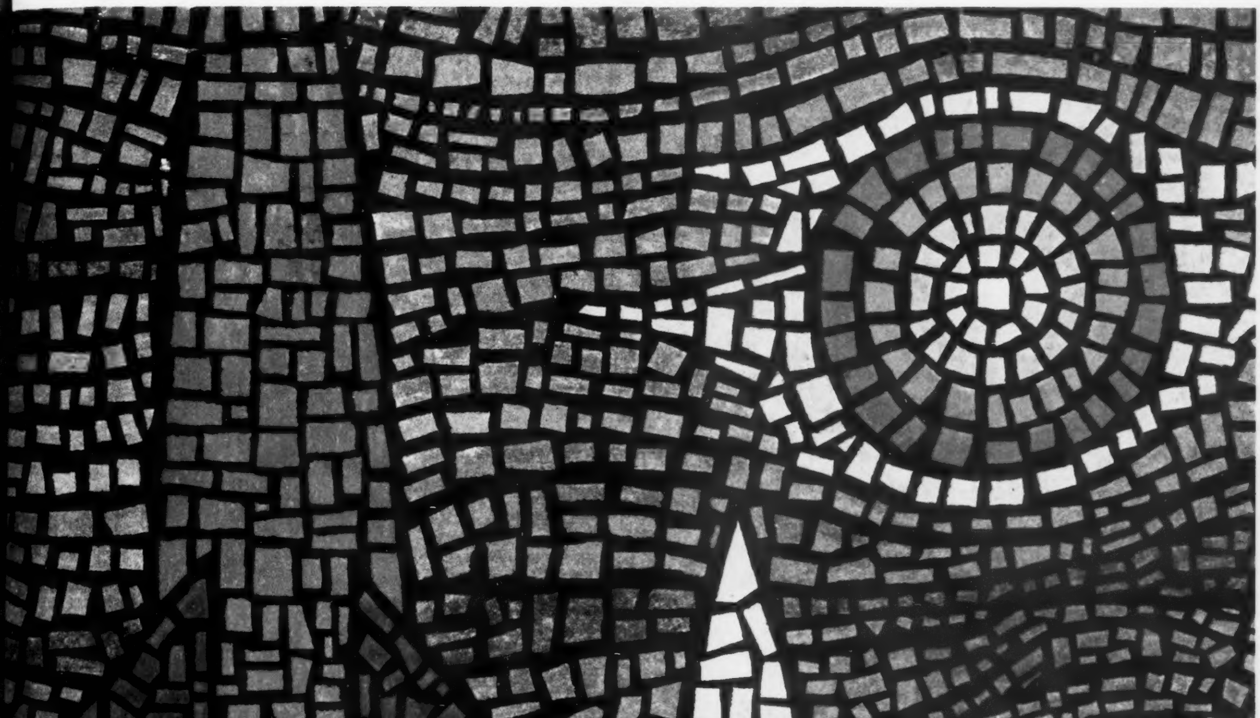
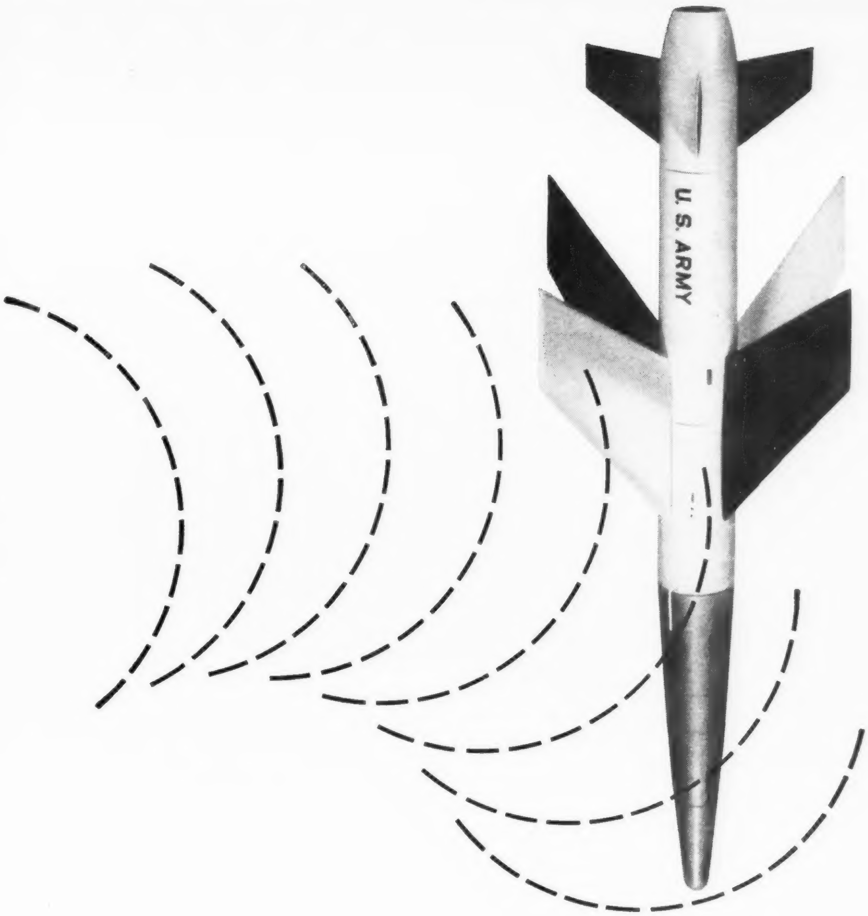
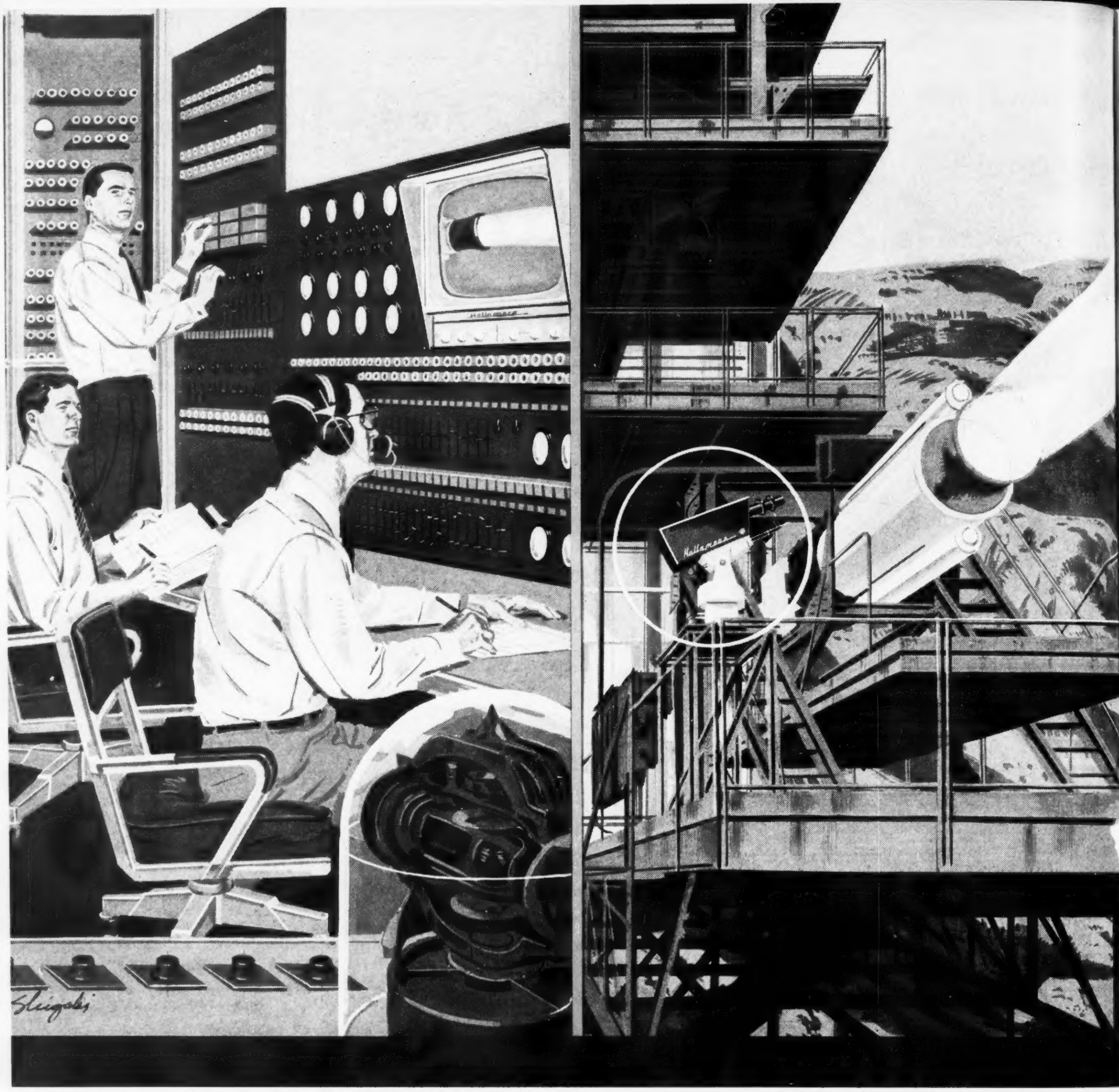
Astronautics

A PUBLICATION OF THE AMERICAN ROCKET SOCIETY

OCTOBER 1957




U. S. ARMY



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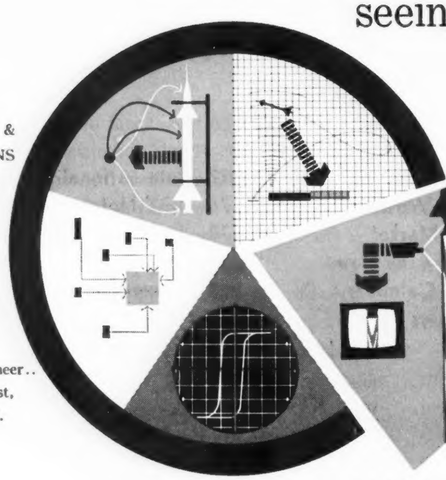

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Far too hot, and positively too ear-splitting, for close, on-the-spot observa by human beings...when high thrust propulsion units are fired up for test Hallamore closed-circuit television takes over the job. Throughout industr similar Hallamore systems are finding application...wherever the requirem is for remote observation or for fast transmission of visual impressions. Hallamore Electronics designs, develops and manufactures missile ground support and in-flight instrumentation systems, magnetic products, electro components and audio visual communications systems. Current activity includes contracts for the United States armed forces and prime contracto of the aircraft and ordnance industries.

-57

HALLAMORE ELECTRONICS COMPANY

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at press time

Up-to-the-minute news about the rocket, guided missile and jet propulsion fields

PROPELLANTS

• A foreign group trying to find a missile propellant market for its nitrogen tetroxide output ran into "an almost complete lack of interest" in the U. S. and is now returning home.

• Stauffer Chemical, supplier of boron trichloride to high energy fuel producers, has a government contract for development of a high energy rocket fuel. The new rocket fuel, says Stauffer, is basically different from present boron-based HE fuels which were developed primarily for air-breathing jets.

Interest in fluorine as possible HE fuel is still very much alive as evidenced by Stauffer's buy-out of fluorine-plant partner Harshaw Chemical in move to step up its R&D program on new fluorine compounds.

• Merger of Liquid Carbonic Corp. into General Dynamics Corp. was expected to be approved at stockholder meetings September 27 to become effective September 30. G-D claims acquisition is strictly for diversification and has no tie-in to Convair Div.'s missile activities.

IGY

• Holdup in TV-2 (third Vanguard test vehicle) launching was due to "usual shakedown trouble" in the vehicle. Cause of the trouble was malfunction of small hardware items such as seals and relays.

• Use of the Grand Central engine as third-stage Vanguard powerplant now seems assured.

• The question of when the U. S. National Committee for IGY intends to institute a high altitude rocket research program in the Antarctic similar to that now taking place at Fort Churchill went unanswered at the recent briefing of scientists about to depart for their Antarctic test stations.

• A Nike-Deacon rocket which reached 410,000 ft at the height of a Class II solar flare is expected to give scientists best first look yet at solar eruptions with a high altitude research rocket, Dr. Richard Porter told the Hayden Planetarium's Earth, Air and Space Symposium.

• An IGY sounding rocket fired from a ship off Greenland found a sheet of electricity 56 miles up, the existence of which had been postulated in theories on causes of the aurora.

PROCESSES

• Big block to use of pure tantalum, niobium, and similar metals as high temperature refractory materials in missile field may soon be a thing of the past. A newly developed vacuum smelting technique reportedly removes interstitial elements, making the metals highly ductile and suitable for working into nozzles and other high-heat rocket components. Stauffer has process in pilot plant stage.

• Commercial jet process developed by Linde Co. Div. of Union Carbide is getting a tough tryout and, says the company, passing it successfully. Tagged Jet-Piercing, the process uses 40 gal of kerosene and 10,000 cu ft of oxygen an hour to produce Mach 5 flame jets with temperatures of 4000 F.

United Waterways Constructors Ltd. of Canada is using Jet-Piercing to remove 3 million tons of rock on the St. Lawrence Seaway project. The process reportedly cuts into rock 10 times faster than conventional drilling methods.

MISSILE CENTERS

• Recent firings from Cape Canaveral—described by the press as "mysterious, extremely fast, new missiles"—are part of a supersonic nose cone research program. The experimental vehicles are not new missiles, not even prototypes.

• Holloman Air Development Center—"we develop missiles, not air"—has changed its name to Air Force Missile Development Center.

R&D

• Success of the Office of Scientific Research offshore research program is expected to lead to further enlargement of research work placed with European scientists and additions to OSR's present Brussels office.

• ARDC's 1958 budget of $661 million—down $41 million from last year—will be divided equally among R&D, planning and development of weapons systems, and "just keeping the 12 ARDC centers going." Wright ARDC will probably get about half of the total R&D allotment.

Although only $26 million out of the $661 million will go to basic research, ARDC points out that this still represents a fivefold increase over four years ago.

• How do men see? As part of its continuing search to find the absolute limit to man's potential, ARDC's Office of Scientific Research is sponsoring work at Ohio State University on how the eye sees.

AICBM

• Army experts visualize anti-missile Nike Zeus—already referred to familiarly as AICBM—as a solid propellant, dart-shaped weapon not much larger than Nike Hercules. It would have nuclear warhead and be able to destroy ICBM's 100 miles from target.

POWERPLANTS

• Static testing of first X-15 rocket engine has started at Reaction Motors. This is not an experimental unit. It is an operational engine (serial No. 1) which has already undergone horizontal and vertical tests.

GOVERNMENT

• Recess appointment of Paul D. Foote as Assistant Secretary of Defense for Research and Engineering is expected to win quick Senate confirmation in January. Conflict-of-interest problems appears to have been ironed out.

• DOD is talking of creating a Liquid Propellants Information Agency similar in purpose and function to existing Solid Propellants Information Agency at Johns Hopkins University.

SPACE FLIGHT

• First man to the moon may be a woman. Letting up from more serious matters, members of an American Psychological Association symposium recently speculated that because of size and certain physiological and psychological qualities, a woman might be the first human to travel to the moon. Dr. Harold Pepinsky of Ohio State University went one step further and suggested that she would be a psychotic midget.

ROUNDUP

• RCA is working on the development of an image converter which will make possible high speed photography with exposures as short as one-hundred-millionth of a second . . . Plessey Co., Ltd. (England), is arousing U. S. interest with its new rubber-on-metal material which is said to absorb radar waves . . . Defense Secretary Wilson indicated U. S. could have an IRBM ready for production in a year . . . Construction has started in Australia on last of 10 Minitrack stations . . . Navy will turn over land-launched version of Talos to Army in official White Sands ceremony this month . . . Chrysler is expected to shut down Redstone production in order to make improvements in new version of missile. Army protagonists say shutdown would be ideal opportunity to switch to production of Jupiter . . . Temco's rocket-powered drone XKDT-1 made successful first flight at Point Mugu . . . Navy has canceled its Triton program after having spent $24 million on development of ramjet-powered guided missile.

ND FACTS

BALL BEARINGS FOR GIANT JETS OR TINY INSTRUMENTS

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FULL SIZE	BORE B FRACTION	BORE B DECIMAL
	3/64	.0469

Nominal Bore	
.2756	.8
.3150	.8
.3937	1.02
.4724	1.10
.5906	1.259
.7874	1.653
1.1811	2.1654
1.3780	2.4409
.3937	1.1811
.5906	1.3780
.7874	1.8504
.9843	2.0472
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NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Columbia Develops Improved Radar

THE "tagged" signal, continuous wave radar system developed at Columbia University's Electronic Research Laboratory makes its significant contribution to the science not for any new principle it adds to the fundamental theories of communications—it adds nothing—but because it achieves the most efficient use of the signal energy while employing only conventional tubes and instruments.

By enhancing the radar signal and, at the same time, recognizing the signal on its return, the CW system multiplies the effectiveness of conventional pulse radar—in range, by as many as 10 times, to about 2500 miles; in precision of the data learned from the echo, by as many as several times at the maximum range.

ICBM Defense

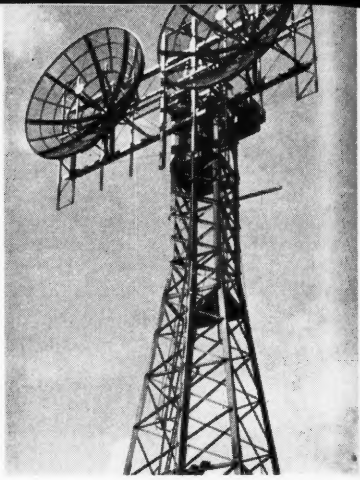
These advances are vitally important in defense against such weapons as the intercontinental ballistic missile. With a longer range, the radar gives longer warning time. With higher accuracy, the target of the ICBM can be more precisely predicted. Because the weapon follows a fixed trajectory once its engines have burned out, its velocity vector and position after burnout determines its path and flight time. A small error in these figures is multiplied enormously by the end of the flight.

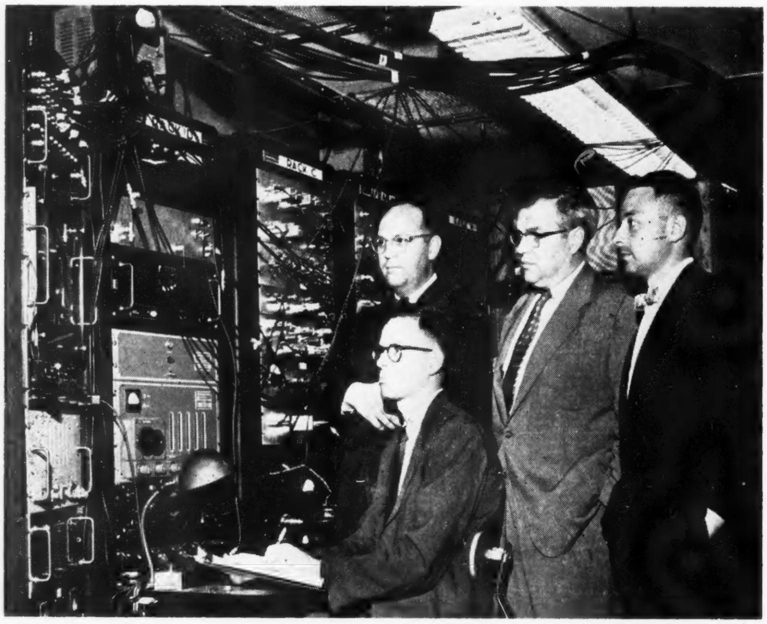
Russia's announcement of a successful ICBM test has intensified the search for an anti-missile missile, and Columbia's radar system may permit a giant stride toward realizing such a weapon. Both Army and Air Force efforts in this field reportedly rely on radar for guidance. If the discriminating radar received can be fitted into an a-m missile's nose, the Columbia system can push the interception area of an ICBM far from United States territory. It has been learned that Ernst Stuhlinger, top missile research engineer from the Army Ballistic Missile Agency, has spent time at Columbia learning about the new development.

Further, the new radar should eventually aid greatly such fields as tracking an earth satellite and certain phases of radio astronomy.

John R. Dunning, a leading physicist and dean of Columbia's School of Engineering, hailed the work as "a first-rate breakthrough that seems to alter the entire concept of how we are going to communicate over long distances and out into space."

The project, centering on fine structure analysis of radar echoes, was supported by a research grant from the Air Force through the Rome Air Development Center. It was headed by Lawrence H. O'Neill, director of the laboratory, with Robert I. Bernstein, associate director, the project coordinator. Responsible for developing the signal transmitter was John H. Bose, while Sterling Fisher was in charge of the receiver.





Columbia University experts who developed the new radar are Sterling Fisher, seated, and, standing left to right, Lawrence H. O'Neill, John H. Bose and Robert I. Bernstein.

Today's pulse radar derives its information from the total amount of energy in each pulse. In other words, its circuitry is based on the envelope of the waves in each pulse. For example, the time interval between pulse transmission and return determines the target distance. Of such a time interval, incidentally, transmission takes up about one thousandth of the time.

Also, to increase the range of pulse system requires simply an increase in power output of the system. Energy is lost in proportion to the square of the distance, so that the strength of the returning echo decreases with the fourth power of the distance. To increase the range tenfold, for example, requires a power hike of 10^4, or 10,000 times.

Columbia's system, called Omni-Range Digital Radar, needs no greater power. It increases radar's range by transmitting and receiving essentially continuously in comparison to pulse duration. It sends out just as much total energy as a pulse system transmits. But it spreads the energy out evenly over the interval during which the pulse system both transmits and waits for the signal return.

FM Wave 'Enhanced'

And the frequency modulated carrier wave (at 3000 mc) has been "tagged" for recognition on return. The wave is not deformed; rather it is alternately crowded together and spaced widely within a given time interval. Thus, instead of relying on the return of the whole signal sent out during a microsecond, for example, ORDIR effectively breaks down the total signal and refers to its component waves for much more accurate measurement of target distance.

Moreover, such variations in the returning signal as that caused by

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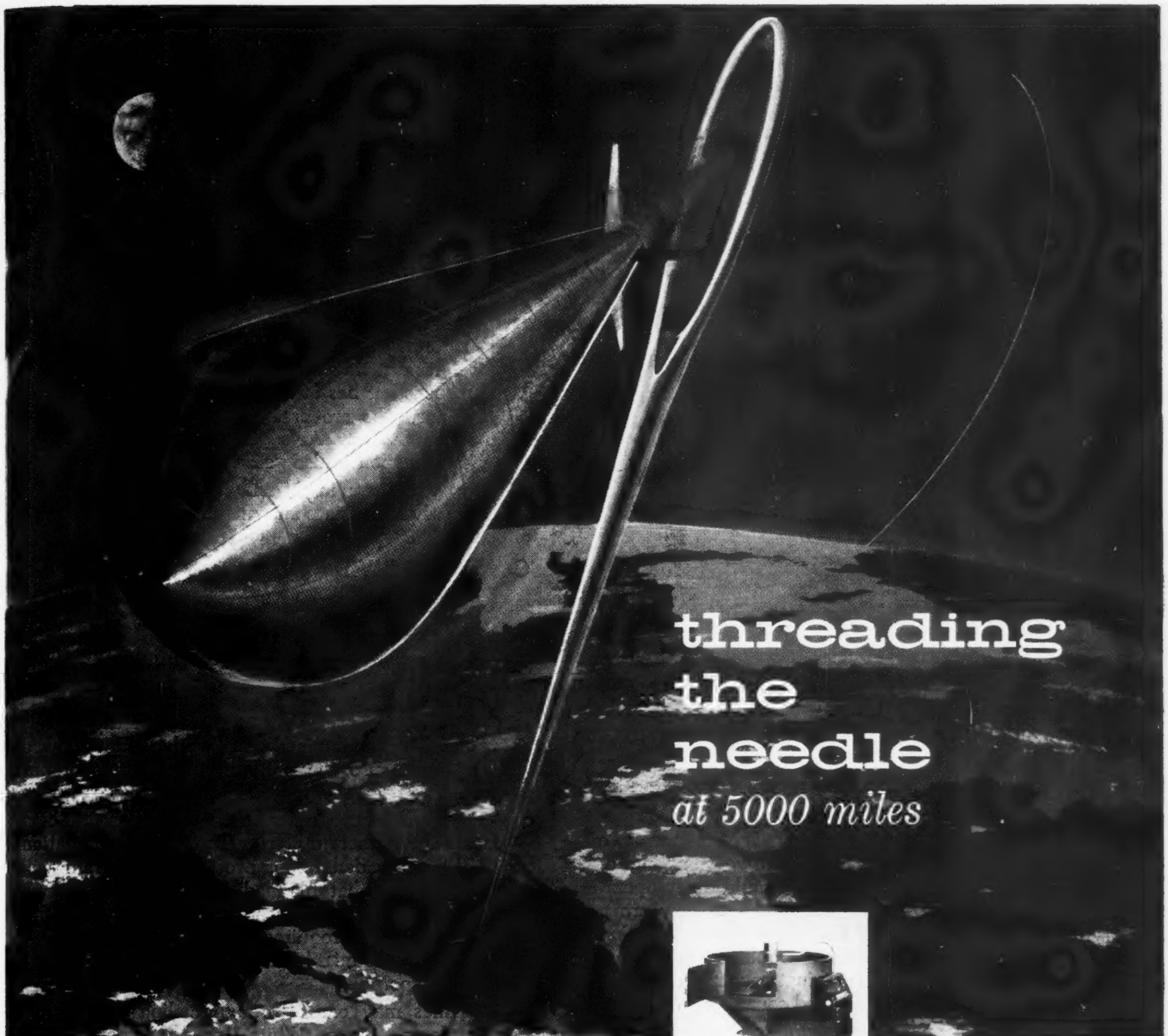

Genisco G-Accelerators play vital role in ICBM development

Threading the needle half-way round the world leaves no room for error.

Inertial guidance—self-contained guidance systems used to direct huge ICBM's to the target—depends for its accuracy upon the degree of internal instrumentation perfection. Switches, relays, delicate instruments, and hydraulic and electrical systems must operate perfectly—even while subjected to tremendous acceleration forces.

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All models incorporate features necessary for critical laboratory testing, as well as the ruggedness and simplicity of operation required for production-line test programs.

Many automatic features minimize operator responsibility and chance for error. Built-in safety features and integrity of construction provide maximum protection to both personnel and machine.

Complete specifications on all machines and accessories are available. *Write, outlining your specific requirements.*

MODEL B78
Accommodates test objects up to 25 pounds; 1200 G-pounds max.

MODEL C159
Accommodates 100-pound test object on each end of boom; 2000 G-pounds max.

MODEL D184
Range of 1 to 800 G's; 1000 G-pounds max.

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Subjects two 300-pound assemblies to 100 G's. 30,000 G-pounds max.

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News highlights from Washington

RUSSIAN ICBM

• Washington refused to panic over Soviet announcement of successful ICBM. Officials were not surprised, intelligence reports of several long-range tests having been received as early as June. (Sensitivity on means U. S. employs to get informa-on Russian program accounts for decision to say nothing.) Knowledge that Soviet missile was a multistage affair of doubtful accuracy and payload also tempered the reaction.

Optimism over Atlas and Titan projects also underlay the mild official reaction. A new Atlas firing was expected soon after the Russian announcement.

MISSILES

• The Army seized upon news of the Soviet ICBM as a lever in its battle to have Jupiter accepted by the AF as its IRBM, but Defense officials seem to lean toward Thor despite the Army weapon's superior test record. They dispute Army claim that Jupiter could go into production promptly, and put heavy emphasis on Thor production line at Douglas. It's also argued that development of ground handling equipment for Thor is further along.

A face-saving shotgun marriage of the two IRBM's appeared likely. Extensive mingling of components from both missiles would delay operational readiness about a year, and that may prove unacceptable in light of Soviet progress. Adoption of Jupiter nose cone to Thor would be least time-consuming of several combinations under consideration, according to informed sources.

• Thinning of missile ranks will be accelerated this winter, barring a reversal of the defense economy trend. Furthermore, heavy pressure for quick braking of expenditures may influence some touch-and-go technical choices. For example, in case of Talos vs. Nike-Hercules, substantial investment in production, handling and launching equipment for latter may give it the edge. Defense officials would like to choose between Sparrow and Falcon, too, but can't because several aircraft have been designed with these weapons specifically in mind.

Most casualties will be among missile projects still in early stages, many never announced, so full death toll may never be known. Defense Secretary Wilson has said flatly that more missile projects were "coming along" than the country really needs.

ANTI MISSILES

• Defense against ICBM's is one of key problems being studied by special National Security Council committee under H. Rowan Gaither Jr. Group is expected to analyze progress in long-range radar, Army's anti-missile project, and means to neutralize nuclear warhead of enemy missiles. Result of this, and broad review of U. S. defense policy, could have important impact on fiscal 1959 budget. Expectation here is that the group, at the least, will give missile-rocket program a push.

• Cutback in research funds for anti-missile missile is being fought by the Army, which thinks its Nike-Zeus program should be given boost as a result of Soviet ICBM announcement. While road is admittedly a long one, Army believes it knows route it must travel to perfect a missile defense system, boasts it has at least a six-month start on the Russians, who are presumed to be studying anti-missile missiles. AF's program for Wizard anti-ICBM weapon is also getting up steam.

• Army expects its Missile Master to figure importantly in ultimate anti-missile defense system.

ECONOMY DRIVE

• Sen. Henry M. Jackson (D-Wash.) has charged that defense economies have caused a slowdown in plans for production of IRBM's and ICBM's. Deputy Defense Secretary Quarles admitted that "missile programs have come under scrutiny along with all other programs as a result of the budget review," but maintained that "we have not allowed funds to injure the program to the best of our knowledge."

• One substantive example of what Sen. Jackson means: Whether Jupiter or Thor or a combination IRBM is decided upon, production program will be less than that planned for either of the two original programs. Reason: Pentagon brass aren't sold on strategic requirement for a 1500-mile land-based ballistic missile, especially if it's liquid propellant type.

• Missiles may crack through ceiling on defense spending set by the White House. Although $19-billion limit on Pentagon spending for first half of this fiscal year is ironclad, budget experts won't be surprised if events force the White House to ease up after turn of the year, with fiscal 1958 expenditures topping the present goal of $38 billion. Official estimate of missile spending for year ending June 30 is $2.2 billion, but $2.4 billion is probably more realistic.

• Detailed figures on ballistic missile spending are classified, but acceleration of programs is indicated by these facts: Four times as much was spent in fiscal 1957 as in 1956; and twice as much will be spent this year as in two previous years combined.

• The defense economy drive sank one of eight guided missile frigates the Navy sought this year, but other requests for missile-equipped vessels were approved.

ARMED FORCES

• Top Defense officials concede that reduction of force at Redstone Arsenal is inevitable when AF take-over of Jupiter is complete, and won't be surprised if there's some break-up of the von Braun team. Army is being urged to concentrate Arsenal's

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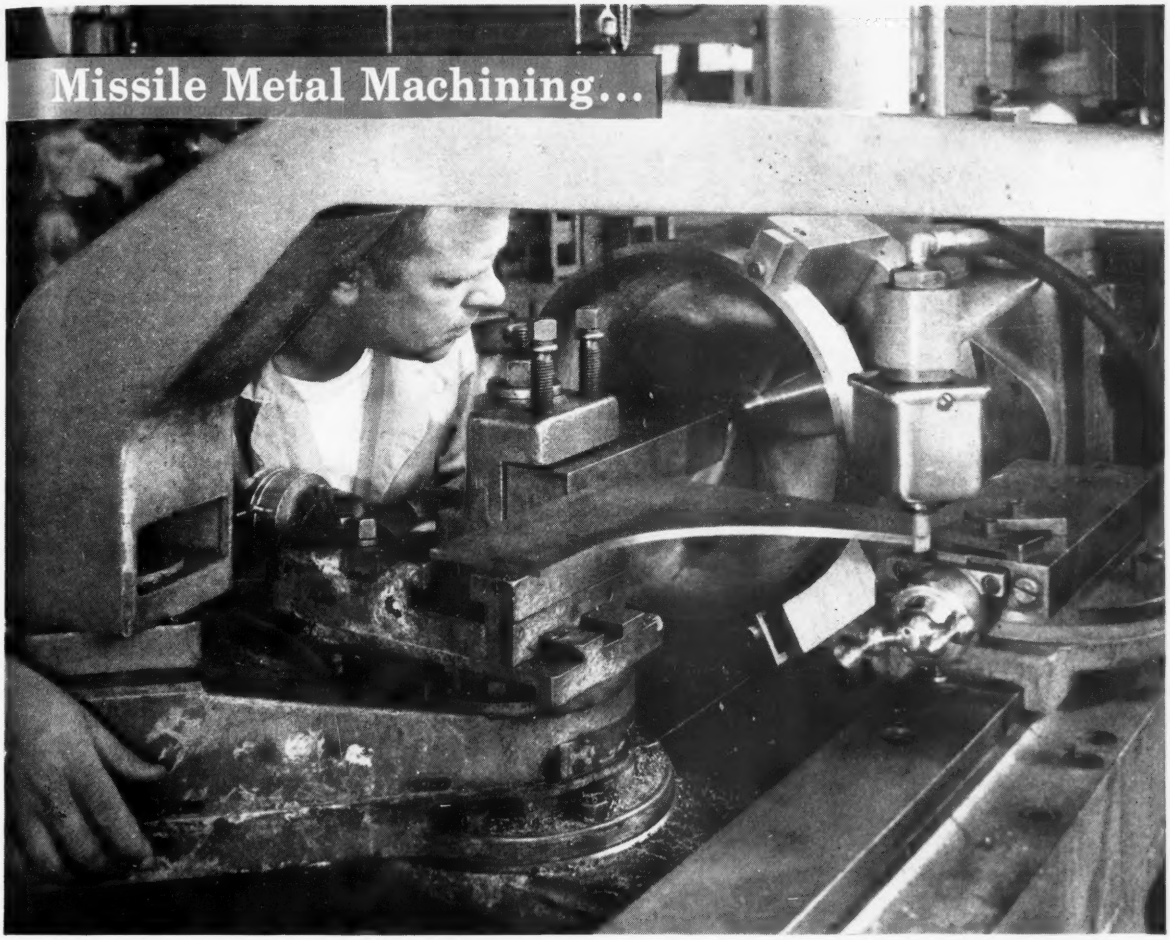

FROM BLANKS TO BULKHEADS!

The Diversey craftsmen above is machining the inner diameter of a Forward Bulkhead of the Hawk missile to a fine 63 microinch finish. Notice the precision curved template in the center of the picture with the follower at the right end transferring the contour to the interior of the bulkhead. Another good example of the famous air gage tracer lathe technique that has brought the missile hardware field to such an advanced state.

Diversey starts with blank forgings. Using their remarkable ability to integrate hydrospinning and contour turning techniques Diversey craftsmen are able to produce the finest and most precise missile and rocket hardware components.

At Diversey you have the LARGEST FACILITIES exclusively devoted to your missile hardware production. Your work is handled by precise, fast, and progressive technical people. Contact Diversey on your tough jobs.

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FROM NOSE TO NOZZLE, FROM FIN TO FIN, CONTOUR TURNED PARTS—WITH PRECISION BUILT IN

Supersonic Seat Test

Technicians at the Air Research and Development Command's rocket sled track on Hurricane Mesa, in southern Utah, load Jato propulsion bottles into an F-102A rocket sled in preparation for a supersonic test of a new ejection seat for "century series" aircraft. The seat is being developed and tested by the Industry Crew Escape System Committee.

Mach 4 Steel

A new stainless steel that retains its high strength at 1000 F was announced last month by Armco Steel Corp. Application to Mach 4 (2700 mph) aircraft and missiles was suggested by the company.

The quality steel is designated PH 15-7 Mo, signifying precipitation-hardened steel containing 15 per cent chromium, 7 per cent nickel, and a small percentage of molybdenum. It is made in conventional electric furnaces and rolled in continuous strip mills, thereby accounting for its relatively low cost.

Other features of the material that will contribute to its value as a metal for skins and major structural parts of flight vehicles are its ease of fabrication and its corrosion resistance.

PH 15-7 Mo is the third of the Armco family of precipitation-hardened stainless steels, a company development. The others, 17-7 PH and 17-4 PH, have been used extensively in flight vehicles, the former in the fuel and oxidizer tanks of the Bomarc. Unlike other chromium-nickel steels that are hardened by cold working, the PH series is fabricated without difficulty, then hardened by heat treatment.

The only competition for the steels is from the titanium alloys, and Armco claims that at temperatures above 500 F, PH 15-7 Mo has higher ratio of tensile strength to density than the standard Ti6A1-4V titanium material. Moreover, the new steel is to be marketed at one-tenth the cost of high strength titanium alloy.

The steel's high strength results from the hardening reaction, which is fostered by 1.2 per cent aluminum. About 2.5 per cent molybdenum provides the unusually good retention of the high strength properties, the company said. Carbon content is below 0.9 per cent.

ICBM's, Russian And American

The recent Soviet announcement of the successful firing of an intercontinental ballistic missile set off a flurry of reports in this country.

Pentagon officials were quoted as revealing that at least four and probably six ICBM's have been tested by the Russians since the spring. The missiles are launched from sites in the northernmost part of Soviet Europe, with the target area in northern Siberia. A distance of 4000–4500 miles was covered by the test missile, one report said.

Shortly after the Russian announcement, Eugene Sänger, famed rocket expert now living in Stuttgart, Germany, reported in a book that the Soviet missile was designed by him and Dr. Irene Bredt in 1942 while working for the Nazi's. The plans fell into Russian hands, it was speculated, when they overran Prussia in 1945.

Dr. Sänger identified the ICBM as either the T-3 or T-4A. T-3 is a two-stage ballistic rocket with range of 5000 miles. T-4A is a two-stage rocket bomber, presumably the antipodal "skip" vehicle that has received wide attention, with a range of 4300–10,000 miles and a Russia-U. S. flight time of $1^1/_2$ hours.

Political and press criticism of the Defense Department for allegedly permitting the Russians to gain the lead in the ICBM race were current, presumably causing the release of information on the United States entries in the field:

- Convair's Atlas, its second known test firing due momentarily, was in pilot plant production, with a full production contract expected by next year.
- Martin's Titan, untested backstop for the Atlas, was only a step away from production, with major segments of the weapon already being turned out in relative quantity.
- An unconfirmed press dispatch from Miami said the U. S. had fired an ICBM successfully more than three months ago.

Finally, as if to show that they weren't scared of the Russian bear, the Defense Department disclosed that it has curtailed expenditures on the 5500-mile weapon. Washington's economy drive forced these "adjustments," which takes the program out of the "crash" category and makes it subject to review along with other military programs. It was expected that the test phases of the programs would suffer most from the cuts, with overtime payments by contractors all but outlawed.

Official reason for these optimistic actions—some observers referred to it as "whistling in the dark"—was the belief that the Russians won't have their ICBM operational for three to four years.

IRBM's Tested

In the wake of the Russian ICBM test statement, dispatches from Cape Canaveral Missile Test Center said both intermediate range (1500-mile) ballistic missiles under development by the U. S. had been tested:

- Army's Jupiter was "a spectacular success" in this latest of many impressive firings, boasted Army Secy. Wilber M. Brucker. The weapon is slightly ahead of its developmental schedule, he added.
- Air Force's Thor, overtly much less successful in its two previous tests than the Jupiter, realized its longest flight time and distance two days after the Army weapon was fired. The Thor vehicle rose gracefully in powered flight for $1^1/_4$ min when a booster section reportedly was disengaged, seemingly to go ahead of the missile, according to eyewitness reports. White smoke then was seen in the weapon's exhaust. Thor wobbled, then left a curving white trail as it presumably plunged into the Atlantic.
- Navy's Polaris, on the other hand, suffered somewhat from the economy cuts at the Pentagon. Magnitude of the slice was not revealed.

In the Jupiter-Thor controversy, still going on though much less blatantly, the procurement policy differences between the Army and Air Force has been emphasized. Army claims its arsenal system is best; the Air Force maintains the superiority of its contractor operation. Secy. Brucker assailed the AF on this management point, contending the Army method "is best adapted to getting the most for the money." Proof, he continued, was in the success of the Jupiter, where the Army had "already accomplished far more than we promised."

Astronautics

OCTOBER 1957

COVER: *"Space patterns," an improvisation on our editorial theme by ASTRONAUTICS Art Director John Culin.*

For Your Attention. . .

IGY 1982–1983 promises to be a much greater "spectacular" than the present one. A panel of top astronauts ponders possible objectives and means of achieving them (page 16). Some thoughts: Nuclear rocket propulsion, manned space vehicles, interplanetary reconnaissance rockets and Mars satellites.

Putting missiles into mass production has raised many problems that even old-line aircraft companies weren't prepared for. The ingenuity with which these problems are met is something to marvel at—and to read about (page 24).

Vanguard is still a major scientific attraction. In this issue, it is the tracking system, projected satellite lifetimes, project personnel and control system that fall under the editorial floodlight (pages 28–36).

In their great rush to rockets and jets, engineers have tended to overlook some interesting and possibly useful, if somewhat unconventional, sources of power (page 44).

Rocket and satellite technology

in IGY 1982-83

Five top scientists see the most spectacular efforts 25 years from now centering on extraterrestrial flight . . . Greater use of sounding rockets, larger and heavier satellites, and more sophisticated instrumentation, permitting elaborate experiments, also envisaged

THE PANEL

Panel Members: *Robert Bush*—Project Engineer, Minitrack Equipment, Bendix Radio Div. of Bendix Corp., Baltimore, Md.

John DeNike—Project Engineer, Advance Design Dept., The Martin Co., Baltimore, Md.

Heinz Haber—Chief Science Consultant, Walt Disney Productions, Burbank, Calif., and Visiting Professor of Engineering, University of California at Los Angeles.

Homer E. Newell Jr.—Acting Superintendent, Atmosphere and Astrophysics Div., Naval Research Laboratory, Washington, D. C.

Milton Rosen—Technical Director, Project Vanguard, Naval Research Laboratory, Washington, D. C.

Moderator: *Irwin Hersey*—Editor, ASTRONAUTICS

Hersey: Dr. Newell, before we get into a discussion of rocket technology in the next IGY, can you give us a brief picture of the general program that you foresee for the next International Geophysical Year, that is, IGY 1982–1983?

Newell: That, of course, will depend a good deal on the results we get from the efforts of the present IGY. As you probably know, this IGY grew out of two previous International Polar Years. These were concentrated on the northern auroral zones, the polar zones. However, when we came to this third Polar Year, the effort just grew beyond the polar regions into something that involved the entire globe.

I think that when we get to the next IGY, the term "International

Speculating on rocket and satellite use in the International Geophysical Year of 1982–1983 are (clockwise beginning at the front left corner of the table): Panel members John DeNike, Homer E. Newell, Robert Bush, Heinz Haber and Milton Rosen, and moderator Irwin Hersey.

BACKGROUND

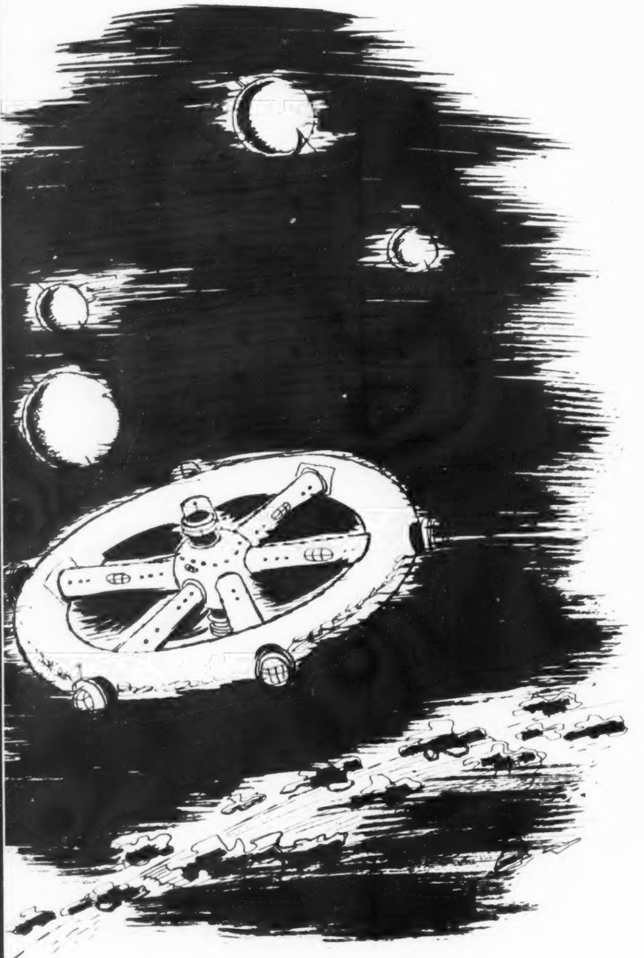
Because of the nature of the rocket industry today, engineers and scientists from different sections of the country seldom have a chance to get together for a good old-fashioned "bull session." One such opportunity does arise, however, when the AMERICAN ROCKET SOCIETY holds its national meetings.

Consequently, the Editors of ASTRONAUTICS decided that these meetings provide an unusual opportunity to bring together a group of people working on related projects for a series of completely informal get-togethers, with the entire discussion tape-recorded, edited and later presented in these pages.

This is the first of these "no holds barred" sessions, held in conjunction with the ARS Spring Meeting in Washington, D. C., and bringing together five men, all concerned to a considerable degree with the current International Geophysical Year.

The topic selected—rocket technology in the next IGY—was designed to evoke discussion of what the next 25 years hold for the rocket industry. That it succeeded in so doing is indicated by the interesting and provocative comments of the panel members.

Look for similar panel discussions in future issues of ASTRONAUTICS.



"Continued use of satellite vehicles—larger ones, big space stations—to study the sky in the visible regions . . ."—*Newell.*

Geophysical Year" may not be comprehensive enough. You may instead want something more inclusive, perhaps to bring in the nearer portions of the solar system, or even to take in stellar studies. In addition, we might perhaps have a longer-term program than we have this time.

I would think that during the next IGY, or whatever it may be called, we will have several things to do. First, we'll have some clean-up work to do to tie up loose ends not completely tied up in the present IGY. Incidentally, I'd like to point out here that the present IGY will produce such a mass of data that we'll be analyzing it between now and the time you suggested for the next IGY. The second job will be to answer new questions that are generated by the current IGY.

Hersey: What major areas of research do you foresee in the next IGY?

Newell: Research areas of major interest that I foresee, to be specific now, would be studies of the sky in the visible regions from satellite vehicles—larger ones, big space stations—in which you can employ proper light-collecting devices with proper optical systems, because you'll be able to handle the weight needed for such equipment; and studies of the sun, the planets and the stars from such stations. The satellite vehicles could also be used to look back on the earth and make a more careful study of it than will be made in the present IGY.

Cooperation Necessary

I'd like to add a general comment on philosophy. In this IGY, one of the major reasons for the globe-girdling effort is that the things we want to study require observation from different spots on the earth's surface.

Tomorrow—that is, in your next IGY—this may not be so true, but you may again want a world-wide effort simply because of the economics of the thing. You may not need to have observation stations all around the world, but you'll probably want to be looking all the time. This is where the world-wide effort comes in, because it means you'll want and need the participation and support of countries all around the world.

Hersey: Mr. DeNike, what do you think about Dr. Newell's suggestions as to what will be needed? Will space stations of the type he envisages be feasible by 1982?

DeNike: Well, it depends, of course, on the size of the payload required, although I do believe it will be feasible to put up large payloads by then. However, I'm not certain the means of propulsion will be chemical. In some studies we have been carrying out, it appears as though large payloads are more economical with nuclear, rather than chemical, energy.

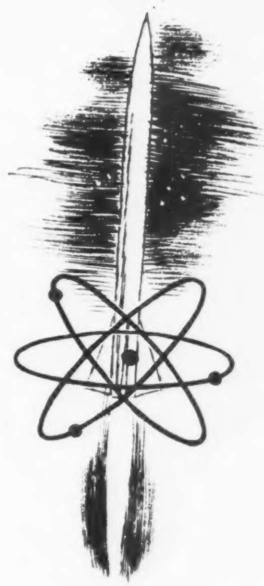
As a result, I would guess, if my glasses aren't too cloudy today, that in this 25-year period we would probably be working more with the nuclear rocket than the chemical rocket. At the same time, I recognize that there are many other exotic means of propulsion being investigated, but these do not look too promising within this 25-year period.

Hersey: Mr. Rosen, how do you feel about this?

Rosen: I agree substantially with what Mr. DeNike has said. For the very large payloads, it appears quite likely we would employ nuclear propulsion.

This ties in, of course, with the question of pro-

pellant-to-gross weight ratios. There's no doubt that present propellant-to-gross weight ratios will increase. However, there isn't too much room for them to increase substantially, and the key to future rocket improvements lies in specific impulse. We must increase the thermal efficiency of the engine before we can take large steps in outer space.



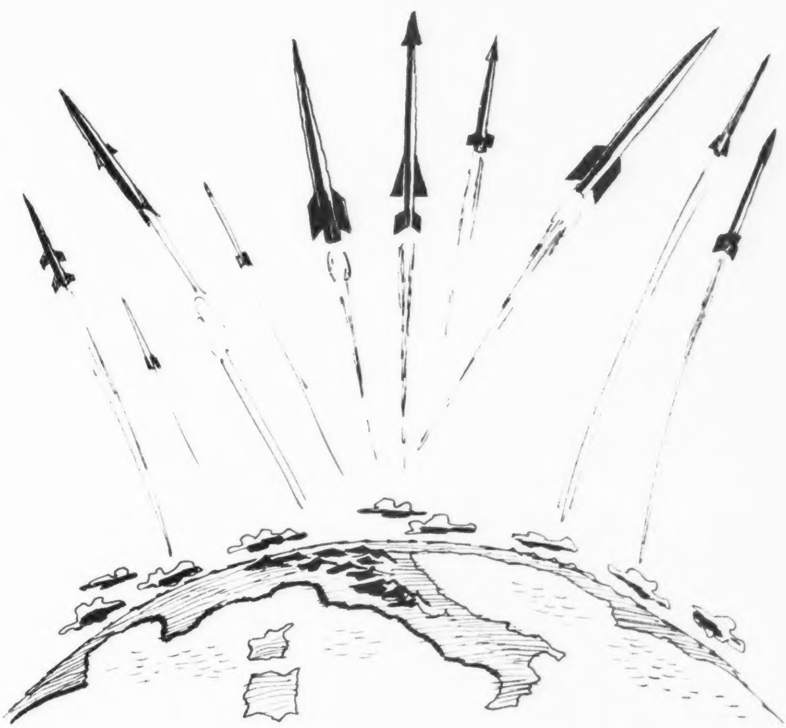
"As payloads increase, it's likely that we'll be working more with the nuclear rocket than with the chemical rocket . . ."—*DeNike.*

Vertical Rockets Will Abound

Space flight will not be the only role rockets will play in the next IGY. You rarely abandon previous techniques. Consequently, I believe we'll be using many more vertical rockets in the next IGY, some going only to heights we now achieve, others going very much higher. They will be more plentiful and practically any nation interested will be able to afford them. Consequently sounding rockets will become a very common tool for geophysical work. They would be used not only during a future IGY, but continually. Present types of rockets, improved and at lower cost, would find extensive use in the future.

Newell: Yes, this is true. I'd also like to point out that the vertical rocket does a different job from the satellite. Very often you find people saying that, when the satellite is perfected, the day of the old-fashioned rocket is done. This is not so; they are doing two different jobs. The vertical rocket gives you a snapshot of a vertical cross section, whereas the satellite is just what we call it—an observation platform which enables you to stay up there and look at something beyond or below.

"Vertical rockets will be more plentiful, and any nation, large or small, will be able to make or buy them, and use them continuously . . ."—*Rosen.*



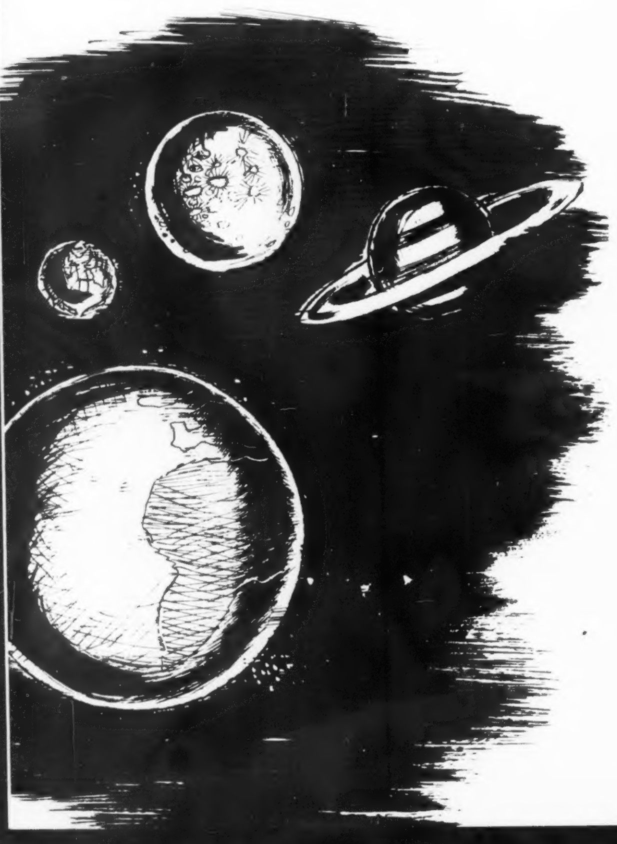
Hersey: Mr. Bush, do you think we'll be able to track and communicate with such satellites or space stations?

Bush: Yes. I believe that, with work presently being carried on in the field of information theory, it will be feasible to carry on communication while utilizing a very narrow band width. I think, however, that we will see a greater advance in the field of data handling and processing. The present trend toward subminiaturization will make it possible for a relatively small vehicle to contain the rather complete data handling system necessary to make communication and tracking practical. In so far as tracking is concerned, I feel that this will be accomplished within the vehicle and position data transmitted to earth via the data transmission system.

Newell: Do you think there will be a significant gain in data transmission and reception, such as with solid state and gaseous "masers," for example, and that this will make a difference to us?

Bush: So far as my knowledge is concerned, I don't anticipate any great increase in efficiency in that respect. There will be some, of course, but not, I think, a phenomenal amount.

"Satellite vehicles could be used to make a more careful study of the earth than will be made in the present IGY, and to study the sun, the planets and the nearer stars . . ."—*Newell.*



Hersey: Do any of you gentlemen envisage the need for a human observer on any of these vehicles, and, if so, what do you see as the major obstacles to sending human observers on such flights? Dr. Haber?

Haber: To take the last part of your question first, the obstacles are quite formidable, and I would just like to run through them briefly, if I may.

Crews Create Problems

The basic obstacle, of course, is the payload. If you send a 150-lb human being into space, I think it's a fair guess that you would need at least a 1000-lb payload for him, in terms of protective equipment and the hardware to get him back. This, I believe, is an extremely conservative estimate.

The next problem is human operation in a vacuum. I think most of you are familiar with the high vacuum chamber built by Litton Industries in Beverly Hills. The chamber is designed to be evacuated to 10^{-7} mm of mercury, in itself a fantastic thing to consider, and they're sending a man into that chamber to find out a little more about the problem. Despite all the safety precautions Litton has taken with the suit to be used and the chamber itself, I regard Mr. Hanson, the project engineer who will be the first to expose himself to this experience, as an extremely courageous individual.

Then there's the problem of cosmic radiation. Present indications are that we should be careful. Dr. Schaeffer of the Navy School of Aviation Medicine some time ago came up with a figure that indicates human tolerance to cosmic radiation, deduced from known data, to be about 15 hours a day. In other words, continuous exposure doesn't look too good at this time.

Other problems still have to be looked into, among them the sensitivity of special organs, and especially the eye, to such radiations. The probability is that, if you have a manned space station with 50 people on it, you would wind up with serious damage, possibly in the form of a cataract, in one eye of one crew member inside of about a week. So cosmic radiation is still something we have to watch.

The third obstacle is weightlessness. You're all aware, I'm sure, of Dr. Siegfried Gerathewohl's work in this field. His basic results show that about half the people he tested enjoyed the feeling of weightlessness, while the others were either indifferent or showed decisive reactions in the form of extreme nausea and severe motion sickness. Those who enjoyed it seemed to be all right, although there were some indications of disorientation even in them. Also, going through periods of weightless-

"Man is a wonderful creature but has the disadvantage of coming only in 150-lb packages, plus the equipment needed to keep him alive . . ."—*Haber.*

ness did cause in all the subjects fatigue and psychophysiological reactions indicative of fatigue and apprehension.

From these factors, it would appear that manned space flight, at least in the foreseeable future, must be considered in terms of missions, as we look on airplane missions today. If you take a bunch of people and put them in a satellite and keep them up there for a month, or even a week, you get a situation equivalent to one in which the crew of a plane would be flying around the world continuously. Fatigue and apprehension would pile up in these people, and I doubt seriously if it would be possible for them to rest properly or to adjust to that utterly unearthly environment to a degree where they could live even a halfway normal life.

So I would say that manned space flight, unless we come up with some fantastic schemes, must be limited to something like 24 or 30 hours, at which time the crew is about ready to go home and get a good night's rest.

Man vs. Instruments

Now, to come back to the basic question: Will manned space flight be necessary to gather the desired information? I don't think it's in the books for some time to come to have a large space station manned by a large number of people staying out there for a week or a month or even longer.

I have such confidence in our engineering knowhow, however, that I feel sure that, with the 1000-lb payload we mentioned, we could put up a series of satellites instrumented on an extremely sophisticated basis.

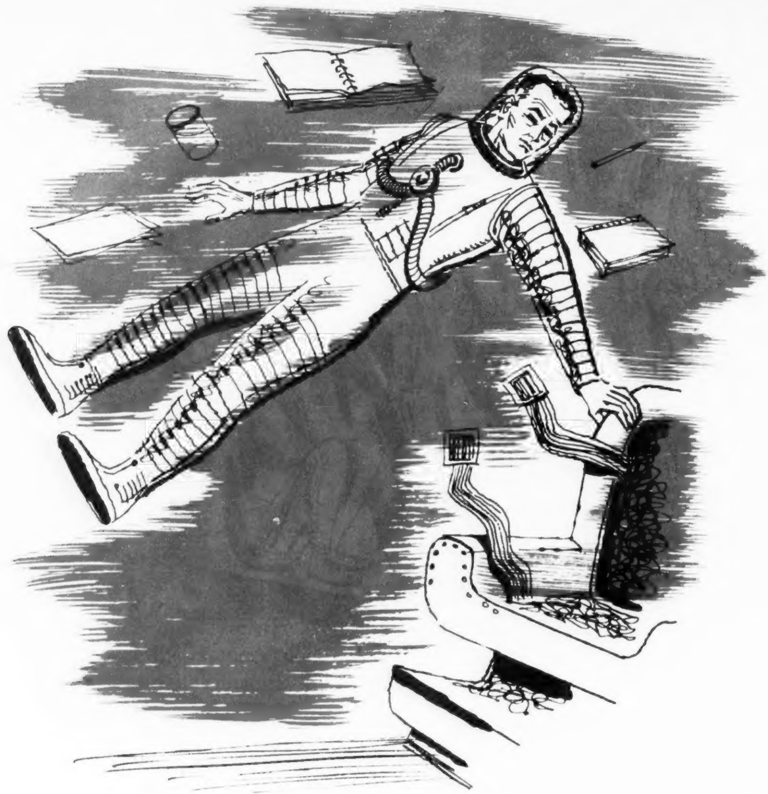
My look into the crystal ball shows the operation in IGY 1982 of considerable numbers of large satellites serviced by manned vehicles of some kind. These will go up there and perhaps reload, readjust or replace equipment in the satellites, and then come back, so that the total mission might not be longer than 12 or 15 hours.

In this kind of operation I see a great future. It will permit us to use man not so much as a biological instrument to make observations for us, but as a means of servicing and getting the most out of the highly developed instrumentation we send up there.

In other words, I conceive of space flight for some time to come primarily as a kind of robot art, toward which we have made fantastic progress in the past 25 years. I feel the tendency will continue to be in that direction. I personally do not see any great advantage in a manned satellite weighing, let's say, 25,000 lb, over 25 satellites weighing 1000 lb apiece, each delicately instrumented and serviced by small manned vehicles in the course of trips, or missions, that last no longer than 15 or 20 hours.

Then I think we're relatively safe in our assumptions as far as the human factor is concerned. I think right there lies our greatest hope for a successful IGY in 1982.

Newell: Dr. Haber, I think it's interesting that a number of us studied the question of what we would like in the way of a satellite if we could have



"Many obstacles still stand in the way of manned space flight. For example, we still know very little about man's reaction to long periods of weightlessness . . ."—*Haber.*

anything we wanted. We all concluded that, for almost any type of experiment we could think of, a 75- or 100-lb satellite would be adequate, assuming we could develop a solar power source that would assure us a continuous supply. And in many cases, we would rather have a lot of these little ones than one great big one, because it means we would not have to put all our eggs in one basket.

Haber: I think that, from the operations research standpoint, this might be a pat solution, too.

Rosen: Dr. Haber, there is one concept you have introduced which is very interesting, and that is the idea of man functioning as a serviceman for satellites. One question I have is: Why do it that way? If you have a 500-lb payload satellite and it fails, why not send up another 500-lb payload satellite, instead of a 1000-lb payload man to service it?

Haber: Now you see why I mentioned operations theory. Man has a tremendous ability of choice and a wide range of functions, but has the disadvantage of coming only in 150 lb-packages, plus the equipment needed to keep him alive. Nevertheless, I can foresee cases in which it might be more advantageous to send a man up there to do something instead of merely sending up another satellite.

Newell: Wouldn't this be true especially if you had a dozen satellites up there? If your man's already up there, it wouldn't take much more energy to move him around from one to another if the orbits were reasonably close together.

Haber: This is correct.

Self-Repairing Satellites

Rosen: It may turn out that there are some operations you'd prefer to have a man doing up there. However, by that time we should have worked out a procedure for bringing the satellite safely back to earth on command. If we learn something has gone wrong with the satellite, we send a signal telling it to come back, and back it comes. We pick it up, service it, and send it back up again. I think we can service it better down here than we can up there.

Newell: One point in this connection. With bigger payloads, you will also be able to make these satellites self-repairing. In this way, you can keep them operating for a much longer time and only bring them back to earth when they've used up all their internal repair capacity.

Bush: I believe this would be a solution. Present experience with data handling equipment verifies the value of dual-channel equipment. A procedure for automatic selectivity is certainly within man's present capabilities.

Rosen: We haven't discussed whether we'll be getting away from near space, or satellite space, in 1982. Will we be able to explore the moon and the nearer planets?

Newell: Well, there's certainly a lot left to be done in ionospheric space, or satellite space, and the attempt to come up with some means of propulsion that will allow us to do that much certainly leaves us with a lot to do. However, my understanding is that, once you've gotten an object out beyond the moon, it takes very little more to throw that object out to Mars.

The big problem comes when you start thinking about getting a lot more payload out there, such as you'd need to carry a man.

Robot Rockets

Haber: Well, just thinking in terms of payload, it's my hunch that we'll explore the other planets by means of robot rockets before trying to get a man out there. I have such confidence in developments that can be expected between now and 1982 that we might well have a Mars project in time for the next IGY, although it might take an international effort to get it off the ground. I envisage something like a 300-lb vehicle, completely instrumented and automatically controlled, with overriding signals controlling it from earth, which could make the trip to Mars, come back and release its information right here.

"Subminiaturization will make it possible for a relatively small vehicle to contain the complete data handling system necessary to make efficient communication and tracking practical . . ."—*Bush.*

Newell: I'm inclined to think that will be the approach, too. That's why I wonder about the question of control over distances of 30 million miles.

Bush: That is probably more of an astrophysicist's problem than one of electromagnetic propagation. I believe that it will be feasible to communicate over such distances, provided there is no interfering factor. I would suspect that actual communication will be spotty, and that a given set of data will have to be transmitted a number of times to assure complete communication.

(CONTINUED ON PAGE 62)

"Considerable numbers of large satellites serviced by manned vehicles of some kind, with man acting primarily as a serviceman for these satellites . . ."—*Haber.*

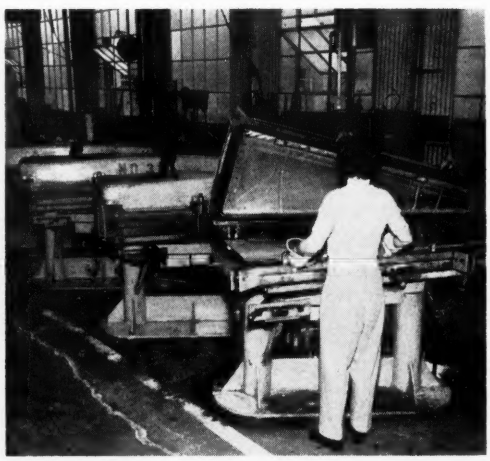
Purchased parts travel down this conveyor and are switched off at stub lines for careful inspection before being used in production of the Nike-Ajax missile by Douglas.

Solving missile production problems

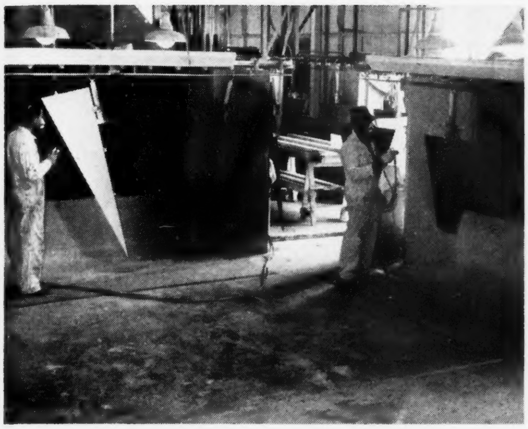
1. NIKE-AJAX

Unique test chamber, dime-store bubble gum, hurry-up paint sprayer were among the answers Douglas came up with in mass production of one of our first operational missile systems

Automatic contouring machine cuts three planes in honeycomb material used for Nike-Ajax fins.



These hot curing dies are used to bond missile skins and cores together.



Nike-Ajax fins are spray-painted in these specially designed booths.

Measuring, identifying and cutting wires for the electrical harnesses used in the missile.

THE pipeline operators who solved their leak-detection problem by running catnip gas through the pipe and then putting a tomcat on patrol duty had nothing on the missile industry.

Douglas solved a similar problem with bubble gum.

The technique, following an employee suggestion, became necessary in production testing of a pneumatic system in the Nike-Ajax antiaircraft missile. Orders called for mass production, and system tests called for pneumatic pressures up to 5000 psi through a maze of piping in the bird's control system.

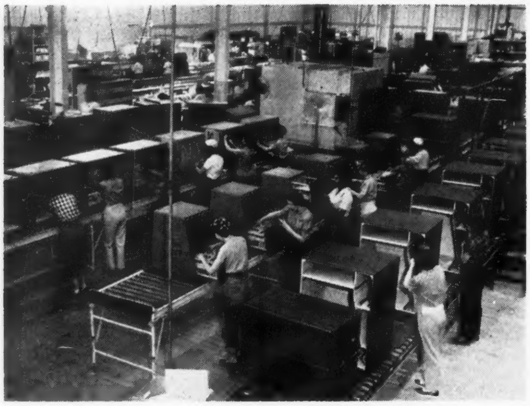
Testing 5000-psi lines does not fit well into conveyer-line methods. At the beginning, the job seemed to call for concrete revetments to protect workers against possible explosion of the whole system.

Douglas met the problem with a unique test chamber that defies disintegration of the missile system. It consists of a coffin-shaped room made of laminated sheet steel with a partially open top to dissipate pressures in case of a blast.

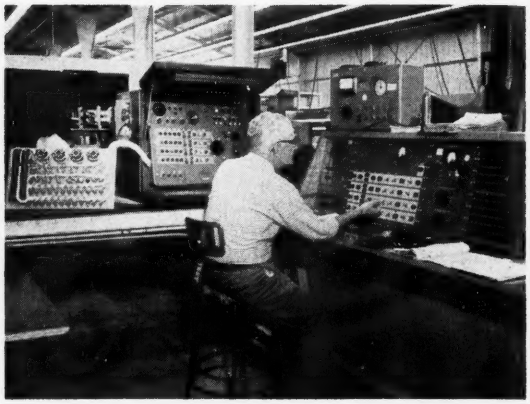
Chamber Was Installed in Assembly Line

A chamber of this type was installed in the Nike-Ajax assembly line. Then came the problem of how to detect incipient leaks. Colored air was considered. This could be detected at points where leaks occurred through observation mirrors which

Mobile wiring jigs to which the wiring harnesses are tied. Harnesses are wired according to diagrams on the jigs.



Wiring of ground control equipment is another important step.



Careful inspection is made of each piece of ground control equipment.

provide a view of the interior from outside the test chamber. But colored air would contaminate the missile system.

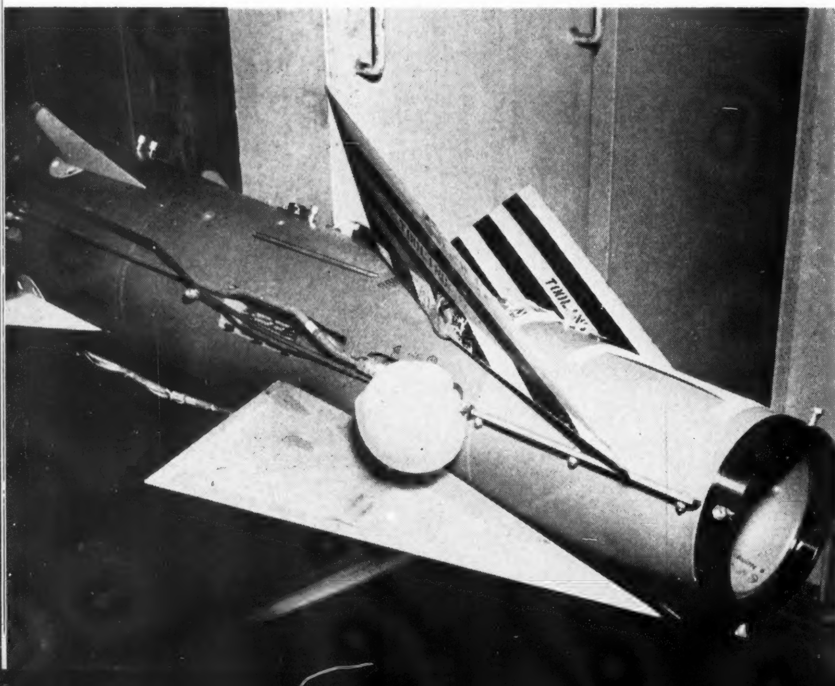
Helium under pressure could not be seen, but could be sniffed. The use of helium, however, would necessitate putting a man inside the test chamber to do the sniffing, and his safety would immediately be in jeopardy.

Raises Bubble over Leaks

The answer was found in a tube of dime-store bubble gum, normally bought by children to produce balloons. Spread over every joint in the system, the compound raises a bubble over any leak, however small. If the bubble breaks, its distorted skin remains to pinpoint the leak. Then the pressure is dropped, the leak resealed and the tests continued. The bubble gum is wiped from the system as easily as Scotch tape is removed, and with as little residue.

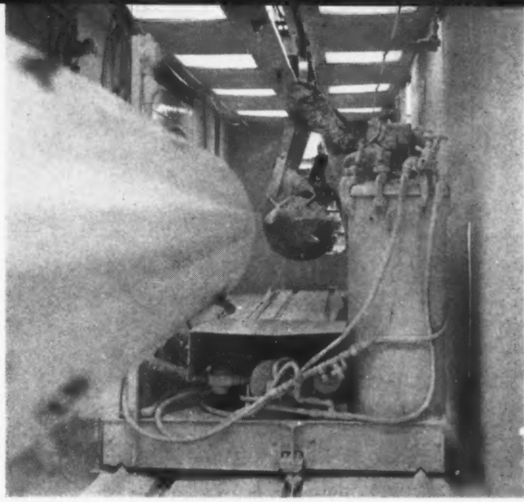
Another production problem centered on the need to mill the contour of Douglas Aircomb, a Kraft phenolic honeycomb structural material, to follow the shape of the structure it was intended to stiffen. Very close tolerances were required, and no machinery existed for this kind of milling.

Consequently, Douglas designed and built a horizontal bandsaw under which the blank core circulates on dolly fixtures. The dolly rides on steel template rails, rising and falling as it feeds the core to the high speed saw to tolerances of $\pm$ 0.010 in. Immediately behind the saw is a band



Nike-Ajax leaving the special test chamber. Bubble gum balloon indicates leak in high pressure line.

Final assembly line. The circular hangers permit 360-deg rotation so all work can be done from above.



This paint booth straddles the assembly line. Mobile paint equipment rides on rails at bottom of booth.

sander that completes the surfacing job.

Painting the exterior of the finished Nike-Ajax originally had all the earmarks of a slow job. Specifications called for multiple coats of enamel which, with drying time, would add up to hours of operation. But there is no time for this on the moving conveyer line on which the missile is hung for assembly.

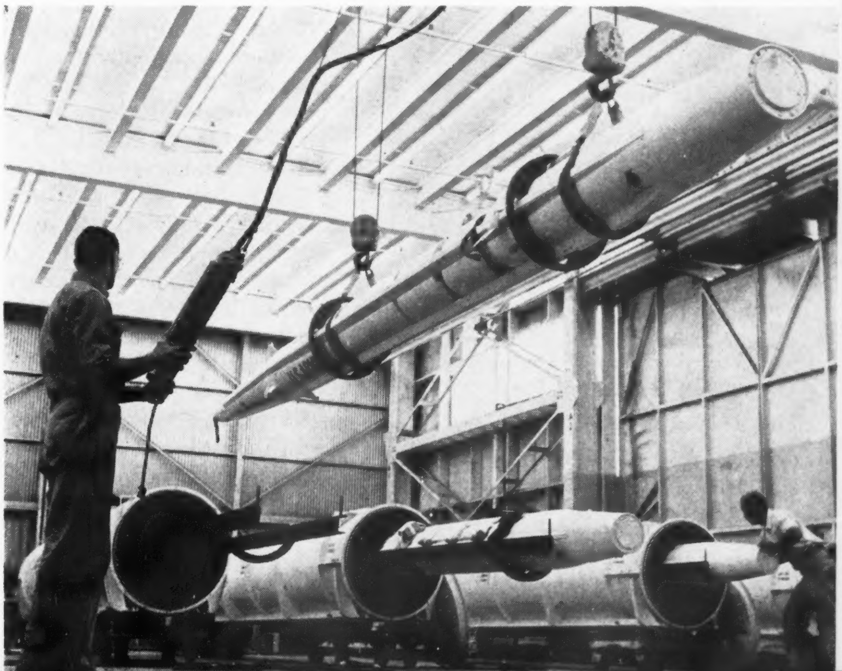
Designed Automatic Spraying Machine

To solve this problem, Douglas designed an automatic spraying machine which, using hot enamel with almost no thinner, places four coats on the missile in 1 min 15 sec per pass. A blast of air introduced into the waterfall paint booth that straddles the line eliminates orange peel of the painted surface.

These are but a few of the problems of mass p o-ducing missiles which Douglas, like other pioneers of the new industry, has had to solve with no guiding precedents. To enumerate them all requires a thick operating manual. As components were released to the family of Nike-Ajax vendors, Douglas passed along their process experience.

Many thousands of Nike-Ajax missiles have been produced at the Douglas Santa Monica Division. The missile, part of one of the first operational weapons systems in modern rocketry, has for years been on guard around American and European target areas. It will soon be supplemented and eventually succeeded by the longer-ranged, more lethal Nike-Hercules.

Missiles are cradled in individual shipping containers and protected from moisture during shipment.



Ear to the sky

A complete report on the Minitrack system, how it works and how it will be used to prove the earth satellite has been placed in orbit

By John T. Mengel

U. S. Naval Research Laboratory, Washington, D. C.

John T. Mengel has been head of the Tracking and Guidance Branch of Project Vanguard at the Naval Research Laboratory, with responsibility for acquiring and tracking the earth satellite by radio methods, since 1955. During his 11 years with NRL, he has successively borne the responsibility for design and fabrication of the research nose shells which replaced the warheads of V-2 rockets fired in this country for high altitude research, headed its Electronic Instrumentation Section and been coordinator of guidance in the Rocket Development Branch. Before joining NRL, he was with GE in vacuum tube development and during the war worked with the Bureau of Ships in the development and evaluation of special detection devices.

TO FULFILL the Vanguard requirement of proving that a satellite has actually been established in an orbit around the earth, it is necessary to track the satellite with sufficient precision so that the ephemerides of the orbit can be published for use by other observers, and so that its lifetime can be predicted.

The problems associated with the tracking requirement are twofold:

1. To acquire the satellite initially after it has been established in its orbit.

2. To track it during subsequent passes and measure its position as a precise function of time, so that its orbit can be computed.

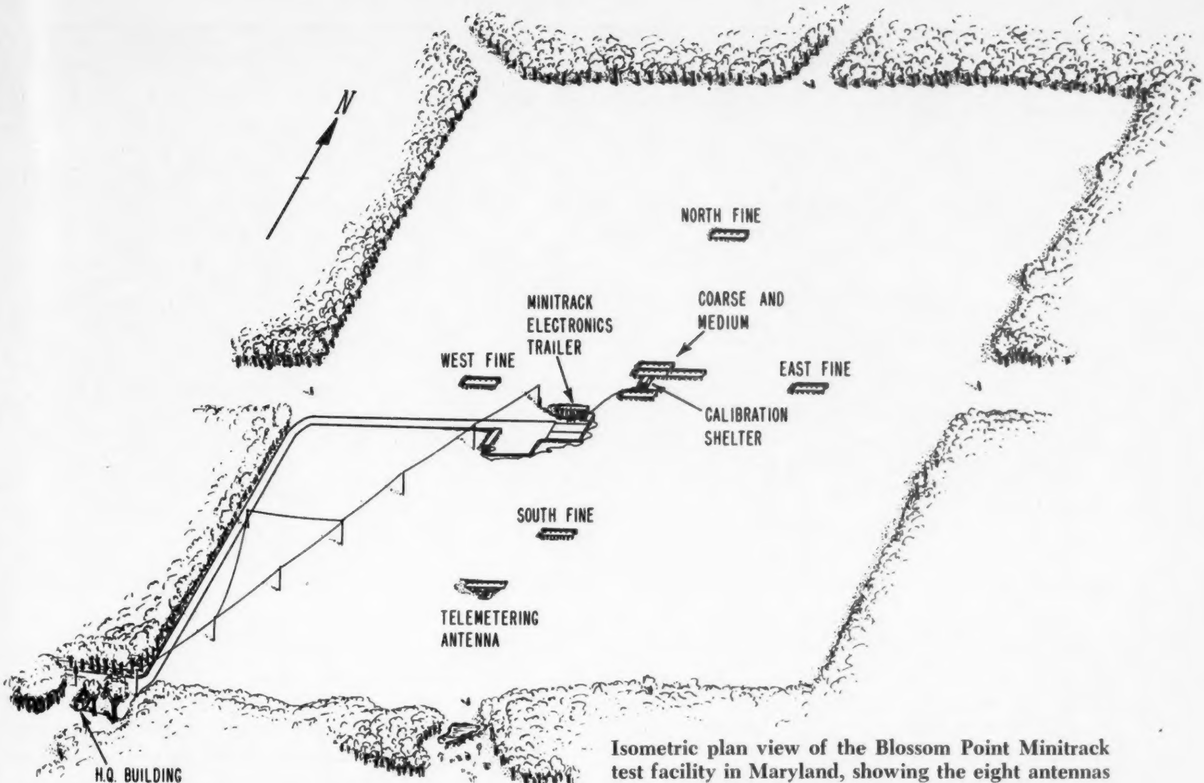
Requirements of the Tracking System

A tracking system designed to answer these two problems must first be able to determine the presence of the satellite and to measure its position with no previous information as to its path, its time of arrival over the tracking site or its speed. Further, it must be able to provide a large number of tracking events during the early lifetime of the satellite, so as to guarantee as much orbital information as possible even for a short-lived "moon."

The mathematical problem of computing an orbit for a satellite of the earth is similar to the astronomical problem involved in determining the orbit of a minor planet. This problem is attacked by measuring the angular position of the planet at six separated locations on its orbit as a precise function of time. These six measurements then provide all the mathematical constants of the orbit of the planet to an accuracy proportional to the accuracy of either the angular measurement or the time measurement.

This same method of orbital determination will be used for the artificial earth satellite. This method of computation affects the tracking problem by requiring that a precision time standard be provided at each tracking station.

The problem of satellite tracking as it applies to the IGY earth



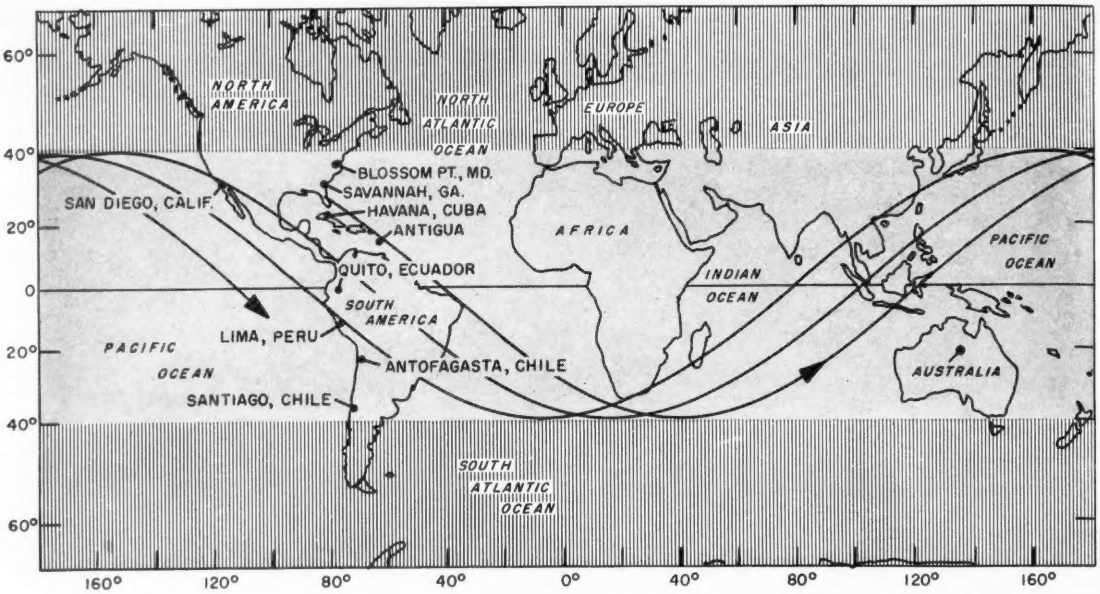
Isometric plan view of the Blossom Point Minitrack test facility in Maryland, showing the eight antennas making up the antenna field.

satellite requires continued operation, independent of day or night conditions, cloud cover or other weather disturbances, and a positive method of identification of the satellite not reasonably duplicated by any other natural or man-made phenomena. The requirement for lifetime of the tracking equipment was established on the basis of the probable length of time required to obtain an adequate amount of data to be used in the computation of an orbit. This time was initially about one week; it has since been raised to about three weeks.

Based on the requirement for continuous, weather-free operation of the tracking equipment day or night, radio tracking techniques were chosen in preference to optical tracking methods. Radio techniques were based initially on both passive systems, where a ground generated signal would be reflected from the surface of the satellite as it passed over both the transmitting and receiving ground stations, and active systems, where a miniaturized transmitter was carried in the satellite to transmit to any number of ground receiving stations.

The latter system was selected for development, primarily because the extreme power required for the ground signal source was impractical, because the use of a ground signal required certain package shape and size limitations in the satellite, and because, even

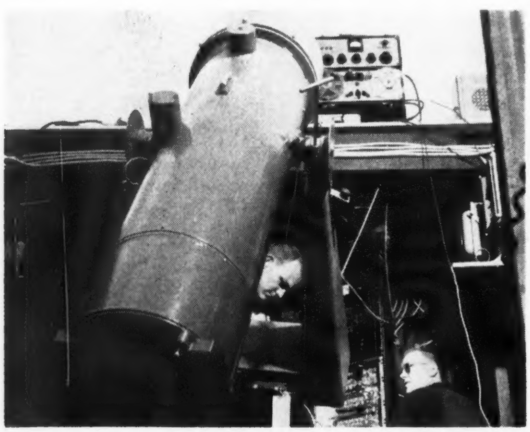
Interior view of satellite tracking van, showing control panels, monitors and receiving and recording equipment.



The network of 10 prime Minitrack (●) stations provides maximum probability of intercepting the satellite.

with subminiature tubes, sufficient power was available in the possible weight allocation within the satellite to make an active system feasible.

The radio system developed specifically for the artificial earth satellite is a radio phase-comparison angle-tracking system named Minitrack, to denote a tracking system with minimum weight within the satellite. As it was originally conceived, a transmitter using subminiature tubes within the satellite would provide a 10–20 milliwatt signal to illuminate pairs of antennas at each ground station. Comparison of the relative phase of the radio signals received by each antenna of a pair would provide a



Calibration camera used to orient tracking station with respect to the stars. Tape recorder in background records calibration data.

measurement of the angular position of the satellite with reference to the line connecting the two antennas. Measurement from two such antenna pairs orthogonal to each other would provide the complete angular position of the satellite. Additional antennas were added as required to provide non-ambiguous angle measurement.

An operating frequency was selected to provide a maximum efficiency of power conversion from battery power to r.f. energy in the satellite; to allow antennas of large collecting area to be used at the ground stations without restrictively narrow beam widths; and to be as far removed from the critical ionosphere frequencies as possible. These requirements were later modified by the availability of transistors for the satellite transmitter to a frequency of not over 135 mc. An operating frequency of 108.00 mc was assigned to this operation.

An isometric plan view of the Blossom Point Minitrack Test Facility, showing the relative position of the eight antennas comprising the Minitrack antenna field, will be found on page 29. The ground station electronics are located in the trailer van, and optical calibration equipment is located in the camera shelter at the exact center of the antenna field. The capability of such a tracking station in terms of angular accuracy is estimated at about 20 sec of space angle for the best conditions of satellite passage, and about 400 sec for the worst conditions, based solely on the effect of the ionosphere at the operating frequency of 108.00 mc. It is estimated that 10 per cent of all (CONTINUED ON PAGE 48)

Will satellites be short-lived?

Consideration of electrostatic drag may cause previous estimates of satellite lifetimes to be halved, NRL scientists say

LIFETIME estimates for earth satellites, up to now based exclusively on drag to the sphere from impinging neutral air particles, may have to be lowered, perhaps by half, to include the effect of electrostatic drag.

This drag results from acquisition by the satellite of a negative charge which increases its effective cross-sectional area. Passage of the satellite through the slow-moving ions of the ionosphere attracts the charged particles. Momentum transfer results, causing the drag.

Two scientists from the Naval Research Laboratory, R. Jastrow and Cabell A. Pearse, have come up with what is believed to be the first quantitative estimate of the charged drag's effect on satellite lifetime. Based on estimates derived from the best available evidence, they predict the drag on the satellite will be comparable to that caused by collisions with neutral air particles.

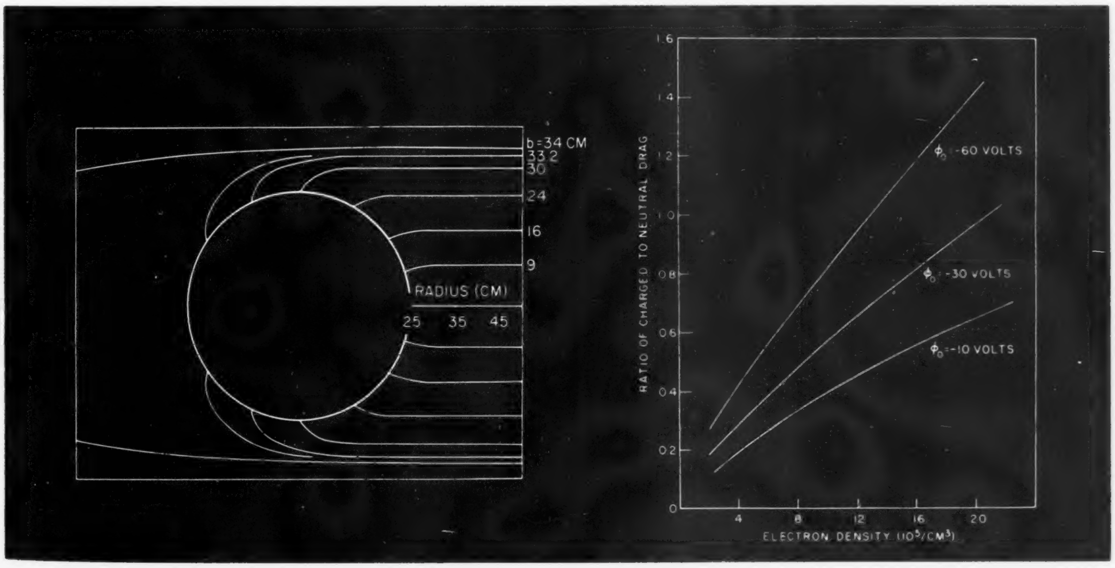
Estimates of satellite lifetimes have ranged from several weeks to 9 ½ years, based wholly on the retarding force from neutral particles. If the Jastrow-Pearse assumptions are correct, charged drag should roughly equal neutral drag, thereby halving published lifetime figures.

However, serious doubts have been expressed that the effect will actually be so great. Several scientists have argued that, even should all forces be maximized and reinforce each other, charged drag should amount only to about 10 per cent of neutral drag. More likely, they maintain, it will be about 1 per cent.

Drs. Jastrow and Pearse based their calculations on well-proven phenomena. In their paper, they noted that electrons move about 60 times faster than ions at comparable temperatures. Thus the flux of electrons hitting the satellite will be about 60 times greater than the flux of ions, causing the sphere to become negatively charged. Rockets fired to less than 150 miles have reportedly become charged to a few volts in this manner.

One crucial estimate among the many necessarily made by the authors dealt with the amount of charge that the satellite would accumulate. They believe the potential will range between 10 and 60 volts for a sphere in (CONTINUED ON PAGE 52)

Ion trajectories for a charged satellite moving left to right are shown in first diagram. Right, charged drag's dependence on satellite potential and electron density is shown for range of 10 to 150 per cent of neutral drag value.



Men of Project Vanguard

Project Vanguard stands as a monument to scientific achievement. But such achieve-

The Navy Team

VANGUARD STAFF at NRL discuss program development. Clockwise from left: Comdr. W. J. Peterson (no longer with the project), Leopold Winkler, Homer Newell, Milton Rosen, Lillian Campbell (secretary to Hagen), John Hagen, James Bridger, John Mengel and Joseph Siry.

KURT STEHLING, head of the Vanguard propulsion group, was among those missing at the time group picture was taken.

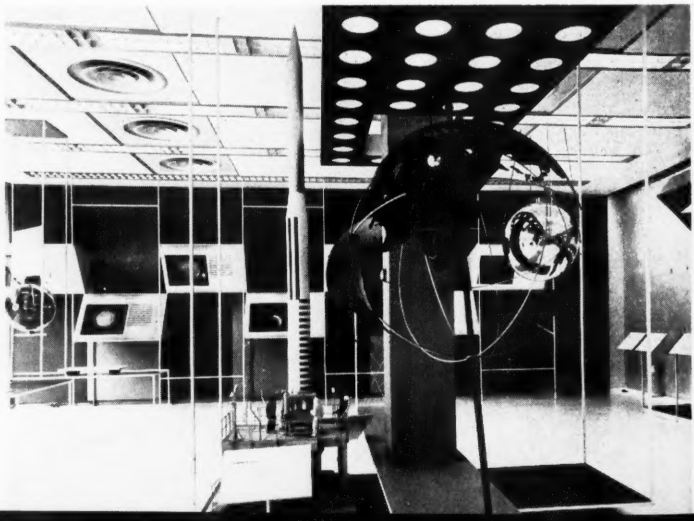
PAUL WALSH, deputy director of project helps relieve Hagen of administrative responsibilities.

ONE Monday morning shortly after the end of World War II, a small group of scientists at the Naval Research Laboratory sat down to plan their future. They had been working on the control of guided missiles; and now that the war was over, most of their projects had been terminated.

These scientists and engineers took a detailed inventory of their collective knowledge, interest and ability, decided on seven major projects that covered most of the missile field as they knew it. Then Milton Rosen, a leading member of the group, came up with a proposal for Project Eight, the use of rockets to explore the upper atmosphere.

On Dec. 17, 1945, NRL's Rocket (CONTINUED ON PAGE 74)

VANGUARD COMPUTING CENTER: Exact calculations for an uncertain future.



ments are the acts of men—in this instance, these men

The Martin Team

By Donald Cox, THE MARTIN CO., BALTIMORE, MD.

PROJECT PERSONNEL: (clockwise) Mel Ruth, manufacturing; Fred Menshing, specifications; Paul Smith, plans; Donald Markarian, engineering; Donald Cox, information; Elliott Felt, operations manager; Joseph Dukert, information; Jack Rogers, sales; Ray Miller, contracts; Walter Stein, finance; Brian Daugherty, procurement; Guy Cohen, quality control.

WITH two successful test shots behind them, a youthful crew of rocket men in Baltimore and Cape Canaveral, Fla., are fast working toward the real thing—the launching of man's first artificial satellite into an earth-circling orbit.

Their brainchild is the three-stage Project Vanguard satellite launching vehicle. And like all fathers-to-be, they are impatiently waiting for the engineer inside the concrete blockhouse to finally press the firing button and, like a doctor slapping life into a newborn baby, bring their brainchild into being. When he does, the rocket will come to life, pass from youth to maturity, and finally die all in a matter of a few minutes. But unlike all previous rockets, the Vanguard will leave behind it in outer (CONTINUED ON PAGE 68)

Donald Cox is himself one of "the youthful members of Martin's Vanguard team" about which he so affectionately writes. His job as information services representative on Project Vanguard is to keep the public apprised through all possible media of the vehicle's progress, almost on a daily basis. It is also his task to try to answer any questions asked by the curious without lifting the security blanket revealingly high. Cox, holder of a Doctor of Education degree from Columbia University, joined Martin only this year after having spent almost nine years teaching at various southern colleges including the Air University in Montgomery, Ala. He is 36 years old and thus, though a latecomer, qualifies as a "Vanguard youngster."

INTERNAL PROBLEM: With aid of cutaway model, Markarian (left) and Felt work out a first-stage structural problem.

The Vanguard control system

Here's how scientists working on the project plan to handle the tricky job of getting the artificial earth satellite into orbit

By Leonard Arnowitz

THE MARTIN CO., BALTIMORE, MD.

PUTTING a satellite in orbit is a ticklish proposition. Too much push at the wrong time and it's off into space; too little, and it's earthbound.

For Project Vanguard—man's first attempt at satellite launching—a circular orbit 300 miles out from earth would prove just about perfect. This would put the satellite low enough to be seen and high enough to stay in orbit for possibly a year. It would also be next to impossible to achieve.

A unique velocity is required to obtain a circular orbit. At an injection altitude of 300 miles, and making no allowance for angular errors, this velocity is 25,025 fps. But there will be angular errors as well as errors in terminal velocity. And such errors will result in the elongation of the circular orbit into an elliptical orbit. The greater the errors, the greater the eccentricity.

Leonard Arnowitz is assistant project engineer on Project Vanguard at The Martin Co., in charge of flight path control. In this post, he heads work on the precision control devices which will assure the release of the earth satellite from the rocket vehicle at the proper altitude and angle. Mr. Arnowitz joined Martin in 1948 after working for a year in electronics at Curtiss Wright. He has a B.S. degree in electrical engineering from Newark College of Engineering and a Master's degree from The Johns Hopkins University.

Have Chosen an Elliptical Orbit

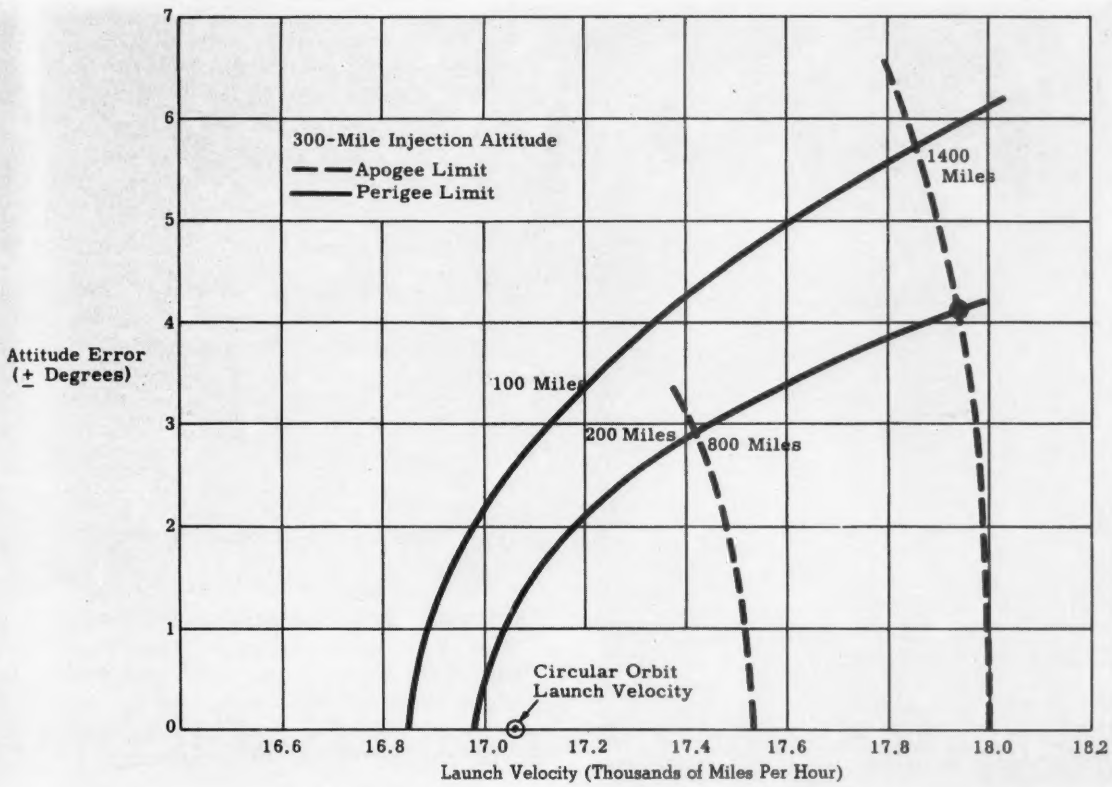
Thus, having little choice in the matter, Vanguard scientists have chosen an elliptical orbit—one with a minimum perigee of 200 miles and an apogee in the order of 1400 miles. This will give the satellite a lifetime of approximately two weeks and, for the most part, keep it within sight and sound of tracking and receiving stations.

But even with a "near"-circular orbit such as this one, allowable errors are small. Attitude deviation can be no more than $\pm 2^1/_2$ deg and the allowable velocity error corresponding to this permissible angular variation is only ± 340 mph, or roughly ± 2 per cent.

Better than a circular orbit that made no provision for errors, the chosen elliptical track still posed a tight design problem in the development of a control system for the Vanguard vehicle. However, a control system has been developed and, it is hoped, will succeed in putting the satellite into its chosen orbit.

The trajectory tentatively selected for Project Vanguard starts with a vertical ascent for a period of 19 sec. The flight path is then programmed along a "zero angle of attack" curved trajectory, which will result in the third stage being parallel to the local horizontal at the time it is fired. To achieve this trajectory, operation of the Vanguard vehicle will be programmed as follows:

Permissible Satellite Launch Velocity and Attitude Errors



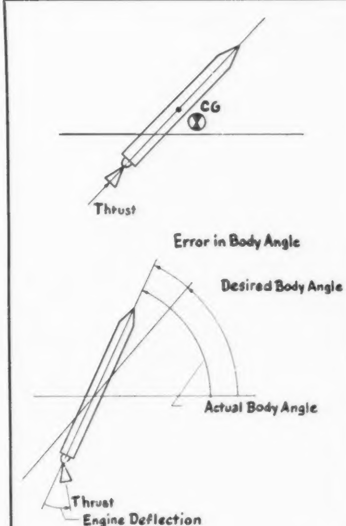
In the first stage, fuel and oxidizer are pumped into the rocket motor, pressurized and burned, producing the thrust required to propel the vehicle. The thrust chamber extends aft of the rocket, is gimbaled in two axes (pitch and yaw), and can be moved by hydraulic actuators.

When no external forces are acting on the rocket, the motor is positioned so that the thrust vector will pass through the center of gravity. If some external force does move the rocket from its proper flight axis, the deflection will be sensed by the reference gyro. The gyro will then send a signal through amplifiers to the hydraulic actuators. The actuators, in turn, will position the thrust chamber at an angle such that movement will be produced to begin rotating the rocket back to the desired flight axis.

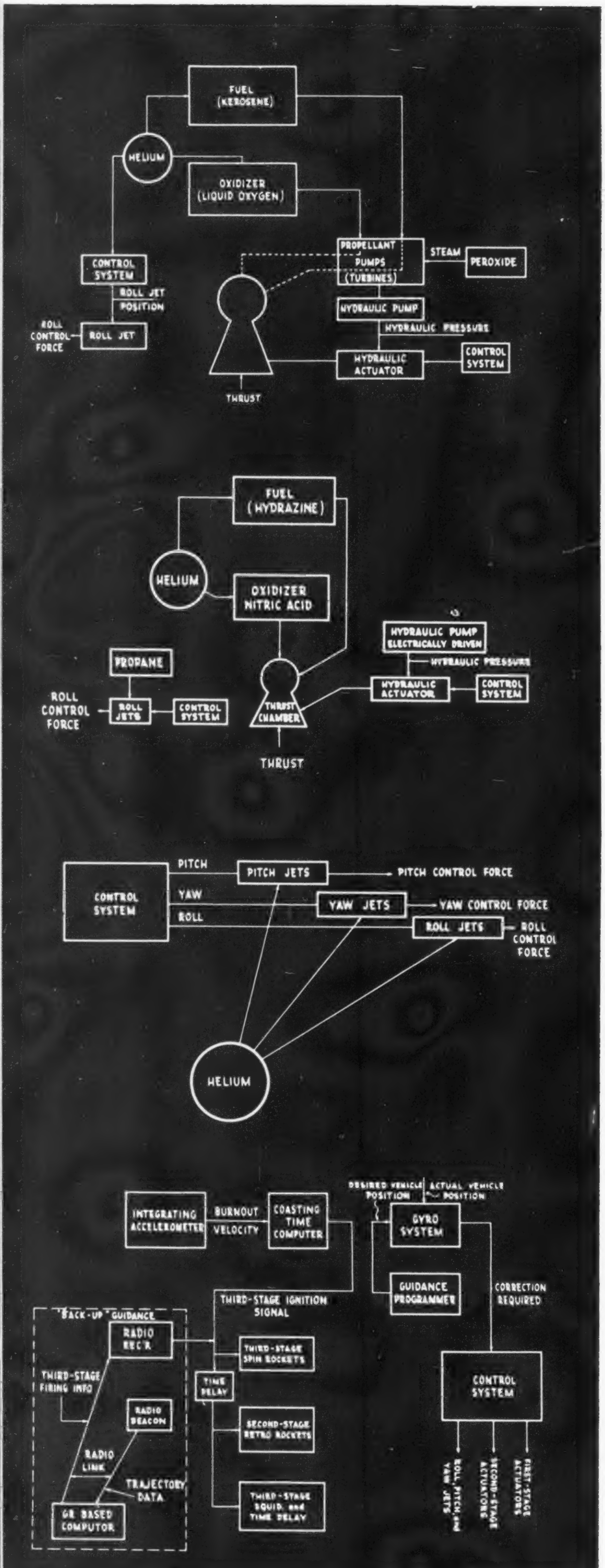
To stabilize the rocket about its roll axis, exhaust from the turbopump (hydrogen peroxide decomposed into high pressure steam) is fed out through a rotatable roll jet. Helium, used to pressurize the propellants, provides the power to move the roll jet in accordance with intelligence received from the control system.

After the first-stage propellants are exhausted and burnout occurs, the first stage is separated from the rocket and the second stage ignited.

In the second stage, engine operation and gimbaling are essentially the same as in the first stage. In place of the turbopump is an electrically driven pump which provides the necessary hydraulic power. Roll control during second-stage powered flight is obtained by exhausting propane gas—instead of steam—through roll jets. The on-off period of these jets is regulated by the control system.



Why gimbaled motor is needed in Vanguard launching vehicle: With no external forces (top), rocket would proceed along normal flight path. By using gimbal as shown above, thrust is directed so as to counteract effect of external forces and keep vehicle on desired flight path.



BLOCK DIAGRAMS of the three stages of the Vanguard launching vehicle demonstrate how the control system operates. Diagrams from top to bottom show first-stage operation; second-stage operation; second-stage operation during coasting portion of flight; and guidance, control and third-stage firing systems.

After second-stage powered flight, the rocket coasts up to the injection point. Attitude is now controlled in pitch and yaw, as well as roll, by jets through which the residual helium gas is exhausted. The jets, in turn, are regulated by the control system. After a certain coasting time, the third stage is separated and fired.

Third Stage Has No Control System

The third stage has no control system. Directional stability is achieved through spinning. The third stage is mounted on a turntable which is part of the second stage. Small spin rockets are affixed to the rim of the turntable.

After the third stage reaches the proper spin rate, small retro-rockets on the second stage are fired, slowing down the second stage and permitting the third stage to float clear. The third stage is then ignited. At burnout, the third stage and coupled satellite are expected to have the proper direction and required velocity for an orbit. At this point, the satellite is separated.

All control equipment, as well as telemetering equipment, radio beacons and radio receivers, is located in the second stage.

Heart of System Is Reference Gyro

The heart of the control system is the reference gyro. The gyro senses where the rocket is with respect to space and compares this with where the rocket should be with respect to attitude at that time. Information on desired attitude is provided by a guidance programmer. Any deviation between actual and desired attitude is noted by the control system, which sends correcting signals to the hydraulic actuators or jet systems, as the case may be.

During the powered flight of the first and second stages, vehicle velocity is computed by integrating its acceleration with an integrating accelerometer which is also located in the second stage. The velocity at second-stage burnout determines the coasting period for the (CONTINUED ON PAGE 84)

Engineer checks 16-in.-diam engine mounted in the NACA Lewis Laboratory 8 by 6 ft supersonic wind tunnel.

Toward better ramjet control systems

Knowledge of the engine's dynamic characteristics is vital in designing such systems. . .Here's a rundown on the techniques, facilities and instrumentation used in experimentally determining such characteristics

By Carl B. Wentworth and George Vasu
Lewis Flight Propulsion Laboratory, Cleveland, Ohio

FOR flight at supersonic speeds, the ramjet engine has the advantage of simplicity and high specific thrust. Further, the ramjet has no highly stressed rotating parts. Thus operation at high flight Mach numbers, where stagnation temperatures are very high, presents no serious problems. It is not surprising, then, that the ramjet has been given a key role in powering some of our supersonic missiles. Many flight tests of both piloted and unpiloted aircraft have established the ramjet as a reliable propulsion device.

We find that the need now exists for a control system capable of maintaining engine thrust in accordance with the requirements of the flight plan and without exceeding any pertinent limits of safe operation.

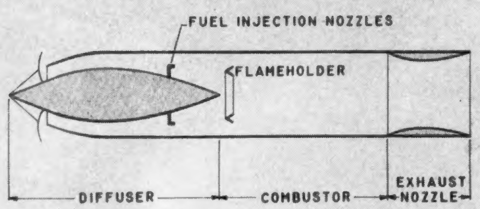
The engineer who must design such a control system asks first for a dynamic description of the engine to be controlled. If this is available, control system design can be approached in an intelligent manner, with little wasted effort. The problem therefore exists of determining the dynamic character of a ramjet engine.

First, let's discuss the particular engine characteristics of interest in control design and then go on to the types of facilities, special equipment and instrumentation that are required.

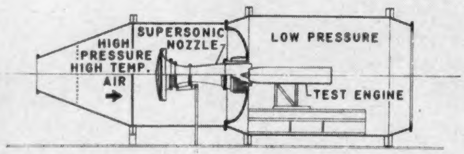
An outline sketch of a typical ramjet is found on page 38. There are three major components:

1. The diffuser, whose function is to slow the in-

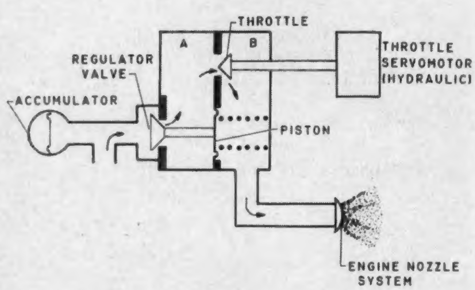
Based on a paper presented at the ARS Semi-Annual Meeting in San Francisco June 10-13, 1957.



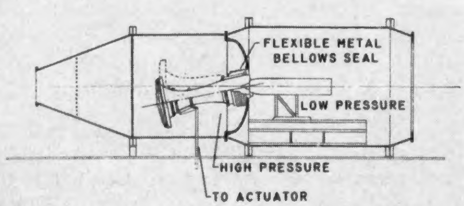
Typical ramjet engine, showing major components.



Free-jet facility, frequently used for simulating the environment of ramjet engines.



Schematic of fast response fuel control valve, used to change fuel flow in the engine.



One method of creating angle-of-attack disturbances in a free-jet facility.

coming air and at the same time to convert the kinetic energy efficiently to potential energy in the form of high pressures. This is accomplished with a conical shock wave and a normal shock wave which may occur either inside or outside the diffuser cowling.

2. The combustor, whose function is to raise the air temperature to a high value by the burning of fuel.

3. The exhaust nozzle, whose function is to convert the energy of the high pressure combustor back once again to kinetic energy. By virtue of the added heat, exit velocities are much higher than the entry velocities, and this is the source of the thrust developed.

Although this sketch shows an engine having a fixed area diffuser and exhaust nozzle, it is quite possible that either one or both could have variable geometry features.

Defining Ramjet Performance

The performance of the ramjet is defined by the relationship between flight Mach number and altitude, the combustor fuel flow and the thrust that the engine develops. Steady-state performance, or the performance when all parameters are constant with time, is obtained by well-documented methods.

However, another aspect of performance pertains to situations where the parameters vary rapidly with time. Such situations arise in flight in turbulent air, or during maneuvers. This aspect of engine performance is called the dynamic response, or simply the dynamics of the engine, and the methods of measuring dynamic response are what we are now concerned with.

It has been found that a definite relationship exists between developed thrust and the pressures within the engine. This permits regulation or control of thrust simply by controlling combustor fuel flow to maintain a particular pressure within the engine. Thus we are primarily interested in the transient behavior of engine pressures in an unsteady flight environment.

Subcritical and Supercritical Operation

If diffuser outlet total pressure of a fixed geometry ramjet is plotted as a function of combustor temperature ratio, we get a curve in which the pressure has a maximum value when the diffuser normal shock is at the cowl. Operation at lower temperature ratios is termed supercritical and the normal shock is within the diffuser. Operation at higher temperature ratios is called subcritical and the shock is forward of the cowl. The engine impulse (cycle

efficiency) is maximum in the region of peak pressure. Therefore operation in this mode is very important.

An engine operating at this point could, with equal probability, be forced into either supercritical or subcritical operation by an unforeseen disturbance. The control, which senses only pressure, must be able to distinguish between the same pressure on the two branches of our curve because the fuel flow must be reduced for deviations in one direction and increased for deviations in the other.

It is clear, then, that the dynamic behavior of the engine in the subcritical regime is important to the control system, so our experimental facilities should permit tests in this range.

The pressure disturbances we are concerned with are propagated through the air stream at the speed of sound, which varies as the square root of the air temperature. Therefore, correct simulation of engine dynamics requires that stagnation temperature of the air within the engine be the same as for the engine in flight. Furthermore, the state of the art does not give us the analytical tools required to obtain full-scale dynamics from scale-model tests. It will shortly be seen that these three requirements –subcritical operation, full-scale models and realistic temperatures–are important in the choice of a test facility.

How are we to provide the realistic environment needed for the engine so that dynamics can be measured? Of course, flight test provides the ultimate in realism, but effective experiments require that most flight parameters be held constant while the test is under way. For unmanned aircraft, this presupposes the existence of an effective control, so if the test were possible, it would not be necessary. We are therefore encouraged to use ground facilities where direct control of flight environment is more readily obtained.

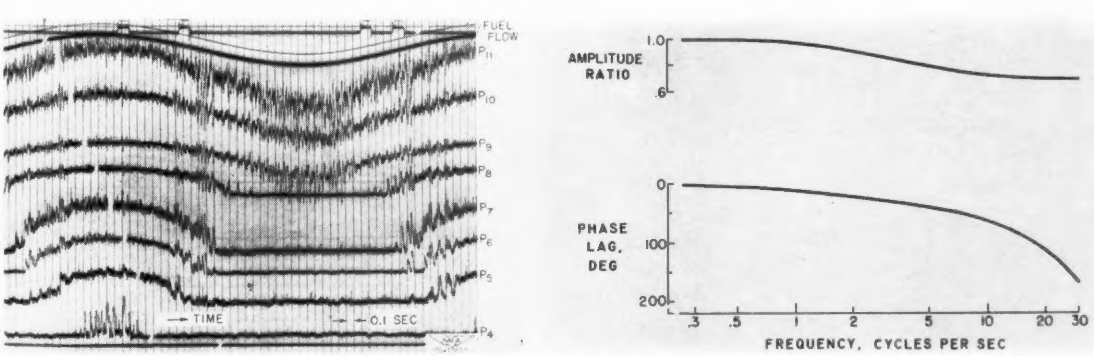
The ground facility which immediately comes to mind is the supersonic wind tunnel. A photograph of a 16-in. ramjet engine mounted in the test section of the NACA Lewis 8 by 6 ft supersonic wind tunnel is shown on page 37. Such wind tunnels provide excellent simulation of flow Mach numbers and pressures both inside and outside the engine, and operation in the subcritical regime is perfectly feasible. There is usually provision in the tunnel to rotate the engine so that good angle-of-attack simulation is available. The tunnel Mach number can be varied by manipulation of flexible throat walls.

Pressure Altitude Cannot Be Varied

Most tunnels in use today cannot be operated as a closed circuit with a burning engine because of the increase in temperature and contamination of the air by the engine exhaust. With the necessary open circuit arrangement, the pressure altitude cannot be varied but will be a unique function of the test Mach number. Thus it is not possible to study the effects of pressure altitude, because it cannot be varied independently of Mach number.

Temperature of tunnel air is limited to values dictated by tunnel wall material and bending stresses in the flexible throat walls. In the NACA Lewis unitary plan 10 by 10 ft wind tunnel, for example, the result of this temperature error at Mach number 3.5 is that the propagation speed of pressure disturbances within the engine is about 25 per cent less than would exist in flight. It is probable, however, that means can be devised in the future to correct this deficiency.

Another method of simulating the environment of a ramjet engine in flight is through a free-jet facility such as that illus- (CONTINUED ON PAGE 80)



Oscillograph record of ramjet pressures during fuel disturbance test (left) and the results plotted (right).

ABMA:

Integrated weapons arsenal

Unique weapons development center's more than 4000 civilian and military personnel can bring missiles from the early design stage to prototype production

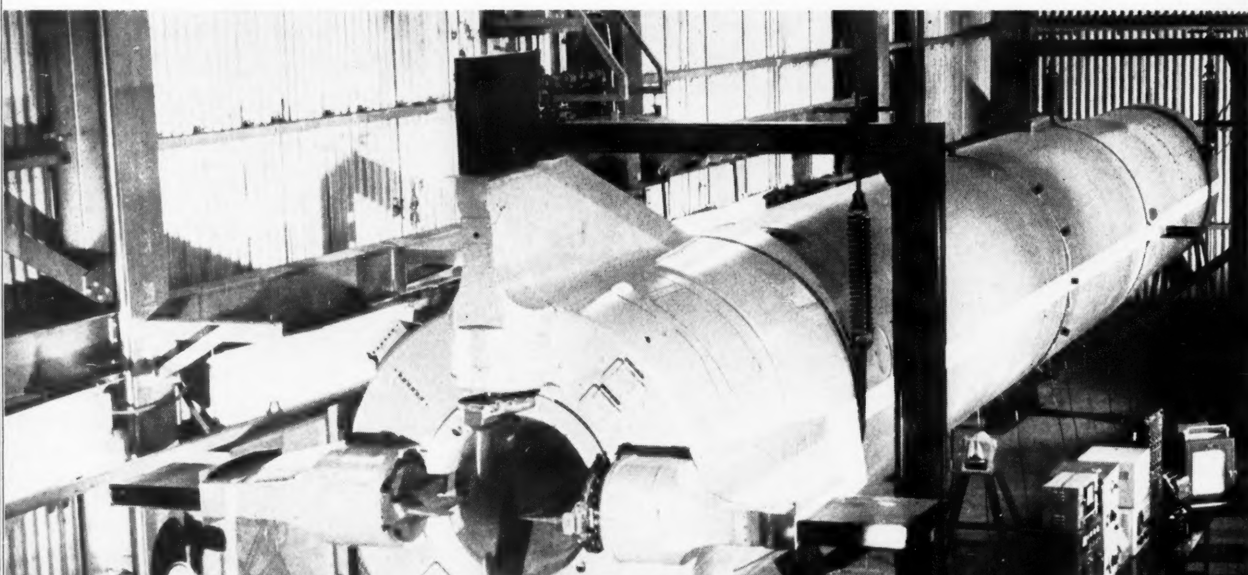
By Gordon L. Harris

ABMA, HUNTSVILLE, ALA.

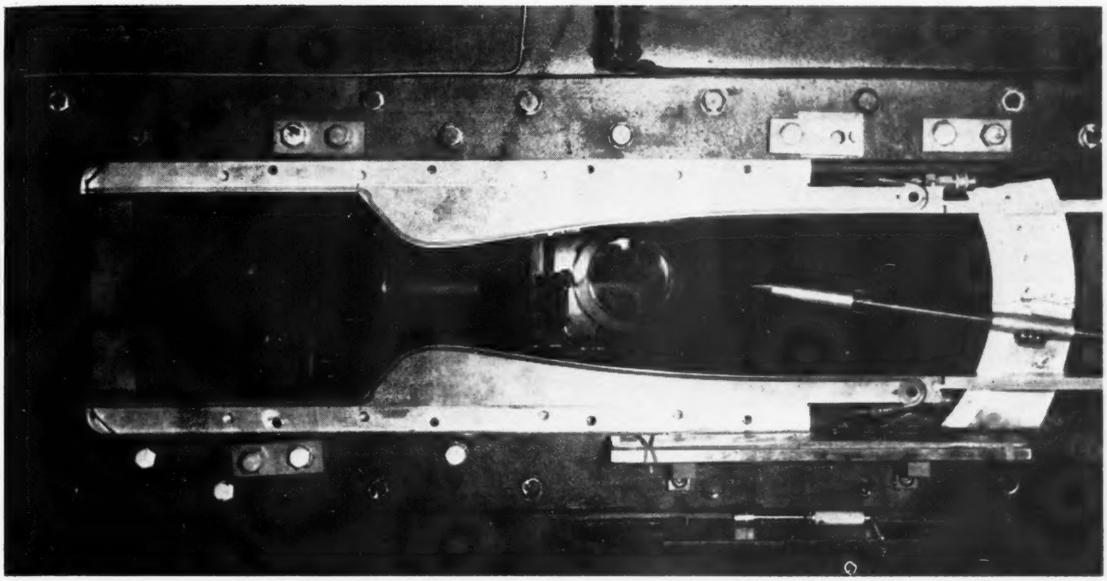
IF ONE word can describe the Army Ballistic Missile Agency, it is "integration." Unique in U. S. weapons development, the Agency carries the integration principle to its ultimate.

• Missile development, from design through prototype production, is worked out by a finely meshed team of more than 4000 civilian and military personnel.

• The military is represented by an integrated staff



Structures and Mechanics Laboratory gives Redstone missile special test before firing.



Missile model positioned for testing in the wind tunnel of the Aeroballistics Laboratory.

composed of the Army's technical service, the Ordnance Corps; its supporting services, Signal, Engineers and Transportation; and its using arms, Infantry, Armor and Artillery.

• Industrial support and production are administered by an Industrial Operations Division, by contractor representatives who follow a project on the spot from the design stage, and by Agency technical representatives at contractor plants.

Maj. Gen. J. B. Medaris commands the Agency, located on the 40,000-acre Redstone Arsenal at Huntsville in northern Alabama. Since being activated a year and a half ago, ABMA has used Arsenal administrative and maintenance services for housekeeping chores.

Facilities Include Nine Laboratories

Physical facilities include nine laboratories, directed by Wernher von Braun; a Research Projects Office under von Braun, headed by Ernst Stuhlinger; and a Technical Liaison Group, of which K. K. Danenberg is chief. In addition, there are Support and Training Divisions under military direction, and staff offices for administration, management, and research and development liaison with other armed services, universities, research institutions and Government agencies.

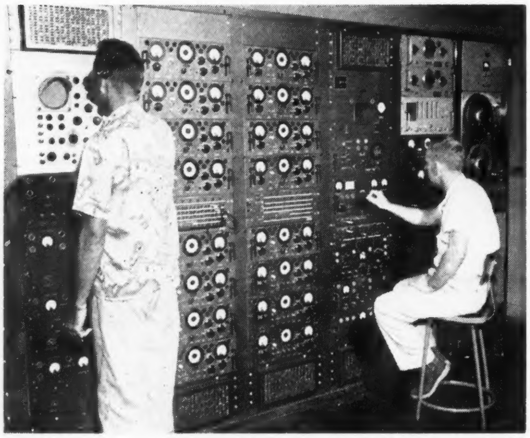
Among the missiles that have come out of ABMA are the Jupiter IRBM and its big brother, Jupiter C; Redstone, Corporal, Honest John, Little John, Lacrosse, and the host of other rocket weapons that make up the Army's missile arsenal.

Fabrications Laboratory Is Largest

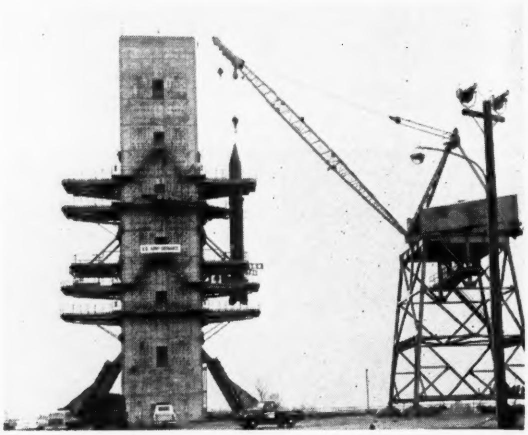
The Fabrications Laboratory is the largest of the nine laboratories. Its main assembly building contains 80,331 sq ft of floor space. Here, complete missile units are assembled, and guidance equipment and powerplants installed.

The lab has facilities for heat treatment, brazing, assembling and press forming operations for components, fixtures and dies, modifications, check-out and storage. There are complete shops for precision machining, welding, sheet metal work, and the manufacture of components, tools, jigs, models and assembly fixtures; and an electrical laboratory for designing and checking out missile electrical systems.

Design, engineering and wind tunnel facilities are provided for in the Aeroballistics Laboratory.



Behavior of missile in flight is relayed to this telemetering equipment in the Systems Lab at ABMA.



Twin-position test tower for static firing of missiles rises 140 ft, takes 500,000-lb-thrust engines.

In the Computations Lab, soon to be housed in a new $2-million structure, is the equipment required for automatic processing of data obtained from missile firings and other uses. The Guidance and Control Lab houses personnel and equipment for research, development design, testing and prototype fabrication of complete systems.

Structures and Mechanics now occupy a number of buildings, but a new, coordinated $4-million laboratory is in construction. The lab is responsible for materials testing and for structural testing of missiles and components. It has separate laboratories for work in rubber and plastics, ceramics, organic chemistry and instrumentation. One laboratory deals with corrosion and surface protection, another with metallurgy, x-ray tests and structural testing.

The Systems Analysis and Reliability Laboratory conducts high pressure testing, analysis and inspection of missile systems. Launching and Handling operates a machine shop for design, modification and engineering of launching and handling equipment.

Operates High Altitude Test Facilities

The Test Laboratory includes machine, pipefitting and electrical shops, a nitrogen plant, propellants laboratory and a compressor station which provides a supply of air up to 5000 psi for use on static test stands and missile pressure tanks. The lab operates high altitude test facilities and vacuum drying equipment; a heat transfer test stand to explore re-entry problems; a measuring center; the 12-story static test tower; a cold calibration test stand for cold flow tests of propulsions systems; and a horizontal firing stand to test rocket engine thrust chambers.

The main effort of the Missile Firing Laboratory is at Cape Canaveral, Fla., where the giant missiles are launched and their performances carefully recorded.

Represents $10-Million Investment

The entire test area, including the test tower, represents an investment of more than $10 million. The tower, a twin-position stand capable of accommodating engines developing up to 500,000-lb thrust, rises 140 ft above the ground. A gantry crane positions missiles for test.

During a firing run, water is discharged across flame deflectors at the base of the tower at the rate of 11,000 gal per min. In a nearby blockhouse, with two stories visible and a third below the surface, are located instruments that can record 500 channels of information.

Once developed, a missile like the Redstone is quickly moved to a prime contractor—in this case the Chrysler Corp.—for production. Chrysler, understandably, has the largest engineering team at the Agency. Other contractors with liaison offices in ABMA include the Jet Propulsion Laboratory, Ford Instrument Co., Motorola, Rocketdyne Div. of North American Aviation, Reynolds Metals Co. and International Business Machines.

Civilian personnel live within a 50-mile radius, three-fourths of them in nearby Huntsville or adjacent Madison County. The Agency's payroll this year will approximate $27 million.

Spawning ground for future scientists

Long Island instrument firm puts high school youngsters to work in summer program designed to interest them in scientific careers

AIRBORNE Instruments Laboratory, Inc., a Long Island, N. Y., electronics firm, has just completed what could prove to be a significant first step toward the development of a large reservoir of top scientific talent from which American industry may draw needed scientists and engineers four or five years hence.

It all started with a request from officials of two near-by high schools for the establishment of a summer training schedule for some selected students. Airborne thought it was a good idea, and worked out a basic plan in cooperation with school officials.

Out of 50 preselected students from the schools, 21 were finally chosen by Airborne personnel on the basis of scientific aptitude and ability, maturity (all students were between the ages of 16 and 18) in deportment and aspirations, and ability to get along with adults and other students.

After getting their security clearances and taking physical examinations, the students were hired early in July at a $1-an-hour pay rate for a 40-hour week. Each student was assigned to a senior technician wherever possible, and for the next two months they were given as many technical tasks as possible. Sample assignments: Soldering, drawing working schematics, machining, drafting and setting up automatic scanners for emulsions exposed to neutrons. In addition, the students attended radar school, learned Boolian algebra, were instructed in the use of the slide rule and engineering handbooks, and so on.

By means of seminars, field trips, association with the company's professional staff and directed group discussions, the students obtained additional insight into the practical, everyday aspects of the scientific life, as well as the opportunities offered for professional development and the rewards inherent in such work.

To further ease the train- (CONTINUED ON PAGE 65)

High school student Stephen Greenberg gets advice from Airborne Instruments engineer Walter Landauer on operation of nuclear emulsion scanner.

Three unconventional engines

The future may produce many new powerplants, unfamiliar to us today . . . Here's a look at three possibilities: The artificial oxidant engine, electrochemical cell, and the oldest engine of all, the human muscle

By Robert A. Gross

FAIRCHILD ENGINE DIVISION, DEER PARK, LONG ISLAND, N. Y.

Robert A. Gross received his B.S. in mechanical engineering from the University of Pennsylvania in 1949 and his Ph.D. in the field of aerodynamics and combustion from Harvard University in 1952 at the age of 24. He was a teaching fellow at Harvard and later worked at Pratt & Whitney. He then joined Fairchild Engine Division, becoming chief research engineer in 1956. He is presently engaged in fundamental research on combustion and supersonic flow, as well as exploratory work on new powerplants.

IN RECENT years, unconventional engines or powerplants have been attracting increasing attention. This subject, in its broadest sense, involves ways and means of converting available energy into useful effort. Of particular interest are energy systems which do not employ chemical hydrocarbons.

Since the turn of the century, a revolution has taken place in methods of converting energy into useful forms. Turbojets, ramjets, rockets and nuclear energy have become major sources of power, and the human effort and funds expended on these systems of energy conversion have been enormous.

Increasing attention is also being devoted to means of obtaining energy from nonhydrocarbon sources. There are many phenomena which physically permit conversion into useful energy. Some of the more unusual ones are photoelectric cells, tidal energy as in the Passamaquoddy Bay proposal, water waves as in "tuned harbors," heat pumps, wave engines, biological photosynthesis, etc.

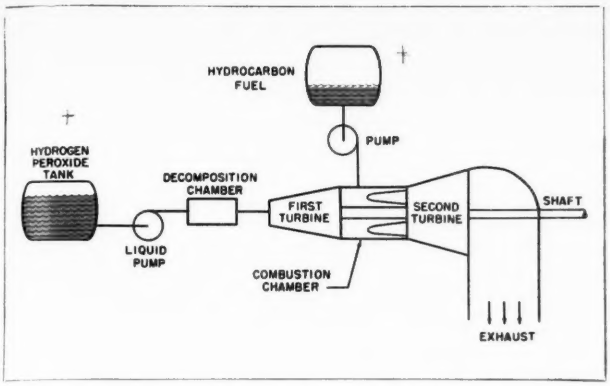
Let's take a look at three such "engines." No particular claims are made for their use or superiority, but they are interesting, and may arouse your curiosity. They are different from the engines common to most engineers and hence the use of the word "unconventional." Moreover, in some cases, they can be used where other more conventional thermal engines of today will not function.

None of them is radically new. But they have not attracted much popular attention. The first is an artificial oxidant engine, which operates on conventional thermal cycles but uses a different working medium. The second may be called an electrochemical cell, which is in reality a steady-flow, primary-type battery. Finally, we'll take a brief look at the oldest engine of all times—the human muscle.

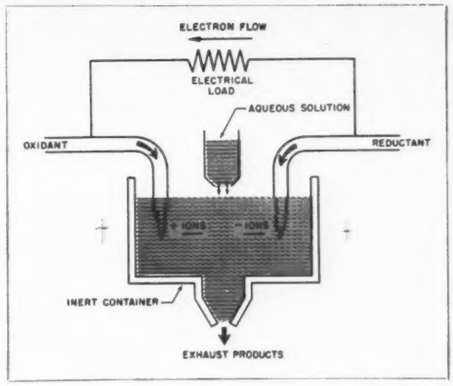
The Artificial Oxidant Engine

Hydrogen peroxide is an interesting substance which has been available from the chemical industry for many years. Its use as an antiseptic and bleach is widely known. In recent years, highly concentrated hydrogen peroxide has become commercially available.

Hydrogen peroxide is a very reactive oxidizing agent and an energy-rich material which decomposes exothermically. It is freely miscible with water and is commercially available in concentrations up to 99 per cent hydrogen peroxide. Ninety per cent hydrogen



A typical artificial oxidant engine. In this case, the medium used is hydrogen peroxide.



Elementary electrochemical cell, an unconventional engine which shows future promise.

peroxide has a boiling point of 286 F and a freezing point of 12.6 F. The concentrated liquid reacts vigorously on contact with many inorganic compounds, such as potassium and ferrous sulfate, and with many other inorganic compounds, such as the phenolics. Its decomposition is catalized rapidly by substances such as oxides of manganese, cobalt, lead and silver, and by metals such as platinum, silver, mercury and others.

In suitable containers free of contamination, hydrogen peroxide can be stored for long periods of time. It has been manufactured, stored, transported and used in a wide variety of power and propulsion systems. It has developed a good safety record where intelligent handling policies have been employed.

Ninety per cent hydrogen peroxide, when decomposed by means of catalytic action, forms a gaseous mixture of roughly 58 per cent water vapor and 42 per cent oxygen by weight. The decomposition is an exothermic process which generates this mixture of water vapor and oxygen at a temperature of about 1364 F. The density of 90 per cent liquid hydrogen peroxide is about 1.4 grams per cc at room temperature. Liquid hydrogen peroxide has been successfully pumped to pressures in excess of 2000 psi.

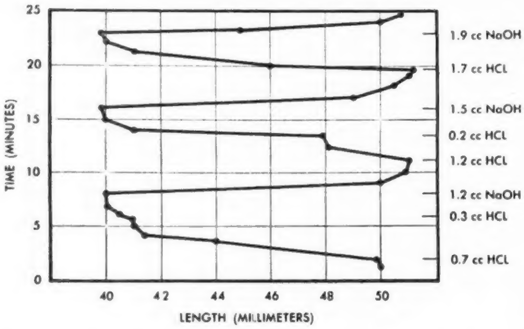
How it Works

Because hydrogen peroxide is a good oxidizing agent, it makes an interesting medium for use in powerplants. One typical way in which hydrogen peroxide can be employed is shown up above. The hydrogen peroxide is stored in a tank, pressurized by means of a pump, and then flows into a decomposition chamber. The decomposition chamber can be a relatively simple device containing a platinum or silver grid.

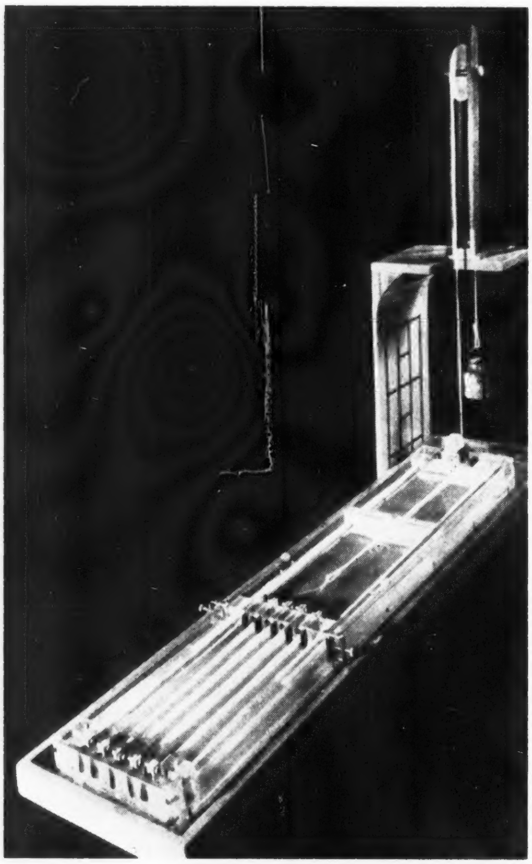
The hydrogen peroxide decomposes, forming a high temperature, gaseous mixture of oxygen and water vapor. This gaseous mixture is at a temperature suitable for current turbine practice. The high pressure, high temperature gas mixture can then be expanded through a conventional turbine. Since the fluid medium is oxygen-rich, combustion may be used to raise the gas temperature. This mixture can then be expanded further through a second turbine to ambient pressure.

Many variations of this cycle are possible. The high cycle pres-

How action of human muscle was simulated in lab tests. Synthetic gels, with weights attached, expanded when dipped into vessel containing sodium hydroxide (left) and contracted when immersed in vessel containing hydrochloric acid (right).



Degree of contraction and expansion of synthetic gel alternately dipped into acidic and basic solutions.



Mechanochemical engine based on the human muscle. Strips of synthetic gel were connected to weight by means of pulleys. When acidity of the solution in which the strips lay was changed, the strips alternately expanded and contracted, lowering and raising the weight.

sure is obtained with negligible work, since it is accomplished in the liquid phase. Because of the possibility of using a high density fluid at the beginning of the cycle, and at the expense of little work, large quantities of power can be extracted from a relatively small, lightweight device.

A similar cycle can be used with the turbine replaced by a piston engine. The basic differences lie in the reduced mass flow rate. Also, the cycle temperatures that can be tolerated are considerably higher than those possible with rotating machinery. For example, a piston engine can be used somewhat like a steam engine. Variations of this cycle can be considered, such as one in which fuel is injected into the cylinder in a fashion similar to that used in the diesel engine.

The quantities of hydrogen peroxide and hydrocarbon fuel required to produce one brake hp per hour are in the order of 2 to 8 lb of fuel and oxidant. The consumption of oxidant and fuel depends largely on the particular cycle considered and the over-all pressure ratio available. This may be compared with fuel consumption of the order of 0.4 lb of fuel per brake hp per hour for an air-breathing engine.

Powerplants that use hydrogen peroxide, however, have abilities that normal air-breathing engines do not have. They can be used in areas where no air is available. Two such regions are currently interesting. One is in underwater vehicles, such as submarines; the other is in outer space. Hydrogen peroxide has already been used in submarine and torpedo powerplants and as primary and secondary sources of power in rocket vehicles. In outer space, cycle pressure ratios of 100 to 1000 are not unreasonable.

The Electrochemical Cell

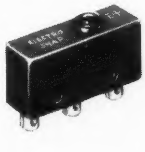
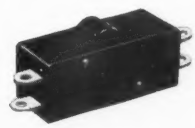
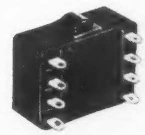
Considerable work has been done on the reaction of lead and lead oxide with sulphuric acid in an electrochemical cell. From a thermodynamic reaction standpoint, this reaction is unattractive, since thermodynamic efficiency is low. However, the potential performance of electrochemical power cycles is very attractive.

Up to the present, surprisingly little attention has been given to the development of primary electrochemical cycles. The fundamentals of a typical cell are theoretically attractive and may be of considerable interest in the future.

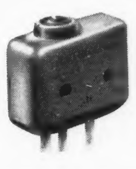
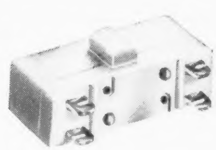
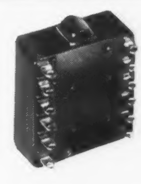
All chemical oxidant-reductant reactions involve a transfer of electrons. The transfer is from the reducing agent to the oxidizing agent. This tie-in between chemical energy and electron transfer is the broad base upon which all batteries, whether of the dry storage or con- (CONTINUED ON PAGE 77)

Switching Problems?...

ELECTRO-SNAP ENGINEERING CAN HELP YOU

	MINIATURES	BASICS	MULTI-POLE
			

DESIGNATION	E4			S1				D8		
CIRCUIT ARRANGEMENTS	SPST NC	SPST NO	SPDT	SPST NC	SPST NO	SPDT	SPDT 2 Ckt.	DPDT NC	DPDT NO	DPDT 4 Ckt.
AMPS-LIFE @ 125/250 V. AC	2.5A—150,000 CYLS.			10A—750,000				15A—500,000		
AMPS-LIFE @ 30 V. DC IND.	2.5A—50,000 CYLS.			10A—200,000				10A—500,000		
TEMPERATURE RANGE	−65° TO +250° F.*			−100° TO +375° F.*				−100° TO +375° F.*		
WEIGHT	.005 lbs.			10 GRAMS				15 GRAMS		
SIZE (INCHES)	27/32 X 23/64 X 0.260			1-1/4 X 1/2 X 1/2				7/8 X 1-1/4 X 1/2		
COMMENTS	Vibration/shock resistant, precise operation.			To 10,000,000 Ops. @ 1 Amp, 125 V. AC.				Simultaneous operation; poles may have different voltages.		

	MINIATURES	BASICS	MULTI-POLE
			

DESIGNATION	EF			G3			K3		
CIRCUIT ARRANGEMENTS	SPST NC	SPST NO	SPDT	SPST NC	SPST NO	SPDT 2 Ckt.	TPST NO	TPST NC	TPDT 6 Ckt.
AMPS-LIFE @ 125/250 V. AC	2.5A—150,000			40A—100,000			15A—500,000		
AMPS-LIFE @ 30 V. DC IND.	2.5A—50,000			30A—100,000			10A—500,000		
TEMPERATURE RANGE	−65° TO +180° F.			−65° TO +300° F.*			−100° TO +275° F.*		
WEIGHT	1 OZ. APPROX.			20 GRAMS			30 GRAMS APPROX.		
SIZE (INCHES)	19/32 X 15/16 X 11/32			1-3/4 X 43/64 X 35/64			1-15/16 X 1-1/4 X .491		
COMMENTS	Sealed against dust, dirt, moisture, and corrosion.			Unusual space/capacity achievement; long life; can be ganged.			Reverses 3 ph. motors to 1 HP. Simultaneous make & break. Excellent life.		

*OTHER MODELS AVAILABLE IN TEMP. RANGES FROM −100° TO +400° F.

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Ear to the Sky

(CONTINUED FROM PAGE 30)

readings will approach the 20 sec accuracy figure. System resolution, not including the antenna and r.f. feed lines of the system, has been demonstrated as better than ±8 sec of space angle over a period of five weeks.

The ground antenna arrays used with the Minitrack system provide a fan-beam pattern aimed at the zenith, with the long axis in the north-south direction. The usable north-south beam width totals 100 deg, and the usable east-west beam width is 10 deg total. To provide the maximum probability of intercept of the satellite within its suborbital zone from about 40 deg S. Latitude to 40 deg N. Latitude, a network of 10 prime Minitracks, shown on page 30, was set up. The network includes nine stations in the Western Hemisphere, plus a station to provide readings nearly opposite this basic fence, at the Weapons Research Establishment at Woomera, Australia. In addition, two similar stations, but with wide angle antenna systems, are being established on the islands of Mayaguana and Grand Turk in the Long Range Proving Ground Complex of AFMTC, for the purpose of measuring the velocity capabilities of the third stage of the launching vehicle.

High Intercept Probability

For a satellite altitude of 300 miles, the seven-station fence approximately along the 75th meridian should provide an intercept probability of about 90 per cent. It is expected that over 20 Minitrack readings per day will result from all 10 prime Minitrack stations. Communications with all these stations will be by teletype lines, both radio and wire, which will connect with the Vanguard Control Center, which will be in over-all technical control of the complete Minitrack network. All tracking data received at this center will be given a quick technical review, and then immediately sent via teletype to the Vanguard Computing Center for orbit determination. Orbital data from the Computing Center will, in turn, be forwarded to the Control Center for dissemination.

As of June 1, five of the 11 complete Minitrack trailer-vans, containing all of the Minitrack ground-station electronics, had been accepted from the contractor, Bendix Radio Div. of Bendix Aviation Corp. Four of these are being tested at NRL. The Blossom Point facility, in operation since July 1956, has been used to evaluate and modify the NRL prototype Minitrack trailer-van and Minitrack antennas, and is presently being used as an acceptance-test point for the Bendix trailers, in addition to being used for training of personnel and finalization of station calibration techniques.

Military Teamwork

The establishment and operation of the stations in the Minitrack network are a joint effort of the U. S. Navy, Army and Air Force and the Australian Weapons Research Establishment.

The U. S. Navy is providing management control of the entire Minitrack network, technical direction at all stations, all Minitrack and telemetering equipment, personnel training, calibration services and the complete establishment and operation of the stations at Blossom Point, Md., and Brown Field, San Diego, Calif.

The U. S. Army is establishing and operating the stations at Santiago and Antofagasta, Chile; Lima, Peru; Quito, Ecuador; Havana, Cuba; and Fort Stewart, Ga. It is also providing the complete radio teletype network between the first four of these stations and the Vanguard Control Center at NRL, plus the wire teletype links between all of the other stations and this Control Center, and supplying instructors to NRL for some of the Minitrack training program classes. Station establishment is proceeding at an accelerated pace under the direction of the Corps of Engineers, using the existing personnel framework of the Inter-American Geodetic Survey in South America and Cuba. Station operation and the communication phases are under the direction of the Signal Corps, both directly and by means of Signal Corps Officers attached to the Corps of Engineers, Army Map Service.

The U. S. Air Force is establishing and operating, through the AF Missile Test Center, the prime Minitrack station on the Island of Antigua and the two minor Minitrack stations at Mayaguana Island and Grand Turk Island, in the British West Indies.

The Australian Weapons Research Establishment of the Australian Defense Scientific Service has agreed to establish and operate a Minitrack station at Woomera, Australia. The Weapons Research Establishment will provide all construction materials, including antenna supports, surveys, concrete pads and hard stands, in addition to operating the station and preparing data for transmission to the Vanguard Control Center.

Cryogenic Conference

Dilution of liquid oxygen in missile oxidizer tanks by the gaseous nitrogen used to pressurize the tank can be reduced by 10 to 20 times with a new nitrogen inlet tube.

Stanley Greenfield of Rocketdyne, inventor of the device, reported to scientists at the recent Cryogenic Engineering Conference at Boulder, Colo., that long range missiles may increase their range by as much as 30 per cent with the tube. Performance of a rocket is greatly reduced through mixing of the oxidizer and the inert gas, he noted.

In operation, the perforated tube slows down the nitrogen gas as it diffuses into the Lox tank at 1500 psi. The gas impinges on the top of the tank, bouncing off gently to blanket the liquid oxygen.

The low temperature conference, sponsored by the National Bureau of Standards at its Boulder Laboratories, also heard about advances in liquefying hydrogen. Freshly liquefied hydrogen boils away rapidly, even in a perfectly insulated container, because its molecules must reorient themselves to the new low temperature equilibrium state. Heat is released in the process.

If allowed to gain equilibrium by itself, enough heat is released from the hydrogen molecules as their spins are changed to boil away 64 per cent of the liquid over a month's time. Instead, an artificial way of achieving the stable distribution—0.2 per cent with a parallel nuclear spin, the rest antiparallel—has been devised by NBS scientists at Boulder.

The liquid hydrogen is passed over intense magnetic gradients to convert the abundance of parallel nuclear spin molecules into the more stable antiparallel spin condition. Pellet or granular hydrous ferric oxide does the trick.

Once conditioned, the liquid hydrogen can be stored for a month with the loss of only 20 per cent to reorientation boiling.

ARDC to Publish Planning Objectives

The banquet address by Gen. Demler at the Gas Dynamics Symposium (see page 58) included indications of ARDC's future plans as they may affect not only Air Force research and development, but also contracts with industry and universities. Gen. Demler also announced that ARDC will publish a series of documents called Research Planning Objectives (RPO's). They cover six AF research areas of particular interest: Propulsion, materials, electronics, geophysics, the biosciences and aeromechanics.

missile market

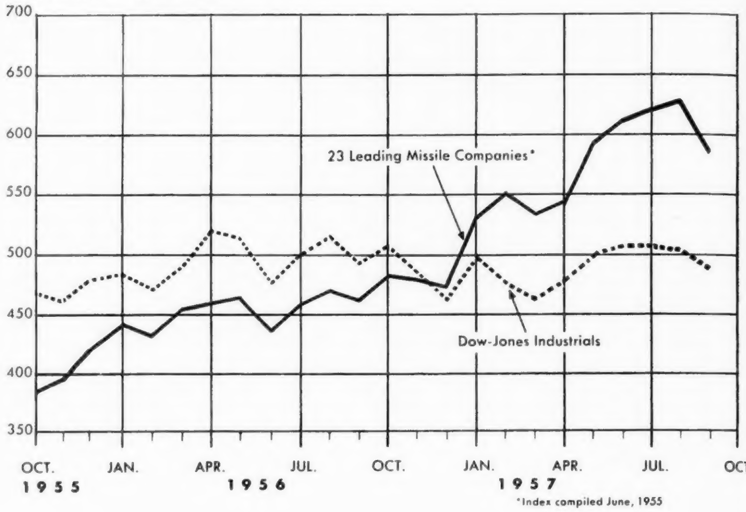
Financial news of the rocket and guided missile industry

BY ROBERT H. KENMORE

WHILE the aircrafts recovered slightly from last month's lows, specialty stocks declined sufficiently to pull the industry index down 11 per cent for the month. Lack of any significant buying support, characteristic of the general market, allowed many issues to slide down on a very small volume of trading. Some of the widest swings were seen in Hercules Powder ($-4\frac{1}{2}$), Thiokol ($-8\frac{1}{4}$), Thompson Products ($-6\frac{1}{2}$), Litton Industries ($-4\frac{3}{4}$), Reaction Motors (-6), Aerojet General (-43), and Marquardt Aircraft (-5).

For the stock market as a whole, as well as for the general economy, there are very few out-and-out bulls left on Wall Street. A general bearish shift in professional sentiment has occurred in the past month—the result of late-summer doldrums of the market, and an awareness on the part of investors that the type of inflation we are in today is not necessarily hedged by common stock purchases. The first of these factors is traditional, as most traders like to wait for post-Labor Day business indications, but the second is a crippling new deterrent to securities sales.

THE MARKET AT A GLANCE



	Sept. 1957	August 1957	% Change	Sept. 1956	% Change
Dow-Jones Industrials	484	505	−4.2	496	−2.4
23 Missile Companies	583	628	−11.1	466	+25.1

Profit Squeeze

Generally, security prices are determined by earnings and dividends, and as prices rise for a company's products its dollar volume increases apace with this inflationary tendency. In the current inflation, however, corporate earnings may be victims rather than beneficiaries, because it is not excessive demand, with its shortages, which is pulling up prices but rather an internal cost push (mostly wages). In so far as corporations are unable to pass these costs on by raising their prices, they will be caught in a profit squeeze which will not augur well either with their earnings or with the price of their securities. This is especially true as per share earnings are further eroded by the dilution resulting from the corporation's continued high capital needs.

Apparently, being bearish or bullish is no longer an answer to successful investing. Wall Street has become unduly demanding on quarter to quarter and year to year results. The fabulous expansion in our post-war economy has led us to such a high base that continued growth of the past magnitude cannot be maintained. On the other hand, it does not seem as though grave economic troubles will cause a significant reduction in business activity.

The answer may be a period of stability and consolidation, with the next big upward push coming in the early 1960's. As far as the market is concerned this can mean a sideways movement for a few years with a central trading range of 450–500. Within that framework, of course, many issues will show considerable declines as earnings fail to increase and price-earnings ratios are consequently readjusted downwards. Other issues will show spectacular gains because of new product development, increased shares of their market, or over-all growth of their industry.

Therefore, it is more than probable that an increasing number of investors will turn their attention to smaller companies who have yet to exploit their full potential and to such dynamic growth industries as missiles, rockets and electronics. Such investments may be considered speculative by the more conservative money-managers, but investments must keep in tune with the times. Yesterday's sure and conservative investment may turn out to be merely an unsuccessful speculation, while the "speculation" made today may be the soundest investment move possible.

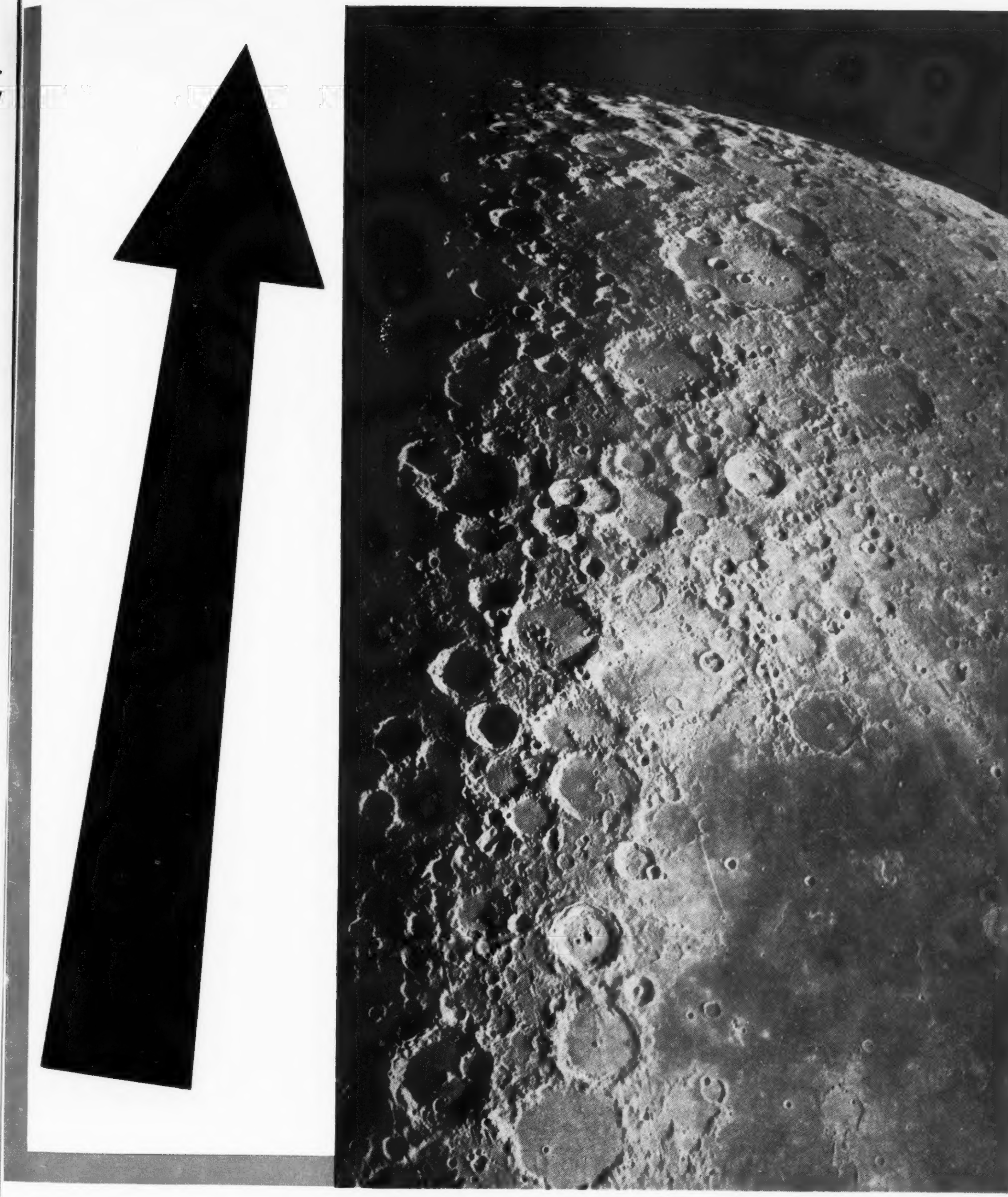
Growth Possibilities

Therefore, in the months to come, various companies which fit into this category will be discussed, starting below with some of the leaders in the rocket and missile field, many of which are now selling well below the year's highs.

Aerojet General—Traded over the counter, approximate price, \$300. Reported for 6 months ending May 31, 1957: Sales of \$80 million vs. \$62.5 million; net per share \$3.88 vs. \$3.75; 431,667 shares of common outstanding, 87.6 per cent owned by General Tire.

Aerojet General is the undisputed leader in the rocket-missile field with 1957 sales projected at \$160 million, an 11 per cent increase over last year. Present backlog (as of July 18, 1957) includes \$170 million in actual contracts with another \$570 million scheduled (although not actually con-

(CONTINUED ON PAGE 85)



Satellites

(CONTINUED FROM PAGE 31)

circular orbit at 300 miles, with air temperature of 1000 C, mean thermal velocity of the particles of 10^5 cm/sec, and satellite velocity of 8×10^5 cm/sec. Electron density is believed to vary around the 10^6/cc value.

To calculate this potential, they assumed a Maxwellian distribution of electrons, with those in the high energy tail of the curve having energies around 60 volts. Further, they estimate that this tail will cancel out the postive charge of the ions striking the satellite surface.

Photoejection of electrons from the sphere by sunlight striking the surface would oppose accumulation of a negative charge on the daylight side of the earth, the authors note. But the magnitude of this effect was not included in the calculations.

For the range of potentials carried by the satellite, effective cross-sectional parameters for the sphere were computed. For a potential of 30 volts, for example, the effective radius would increase half again as much as the 25 cm of the sphere, and the effective cross section for collisions with ions would increase to $2^1/_4$ times that for neutral particle collisions.

Ions that would have passed close to the surface of the satellite are thus drawn to the sphere to transfer momentum both in striking the sphere and in recoiling, as neutral particles, from its skin. The chart on the left would increase to $2^1/_4$ times that for a satellite carrying a 30-volt potential, assuming an electron density of 2×10^5 electrons/cc.

Contributing between 30 and 50 per cent more drag are the four 75-cm long antennas that extend from the satellite. On the basis of a mean antenna radius of 0.4 cm, the authors compute an effective radius of twice that value.

The chart on the right on page 31 shows the relationship between charged drag on satellite potential and electron density for the satellite less antennas. The Boltzmann constant k times the electron temperature T_e is taken to be 1.5 electron volts.

The authors formulated a neutral drag equation, considering specular elastic and diffuse elastic reflection of air particles to be the extremes. At 500 km (300 miles) above the earth, with a neutral air density estimated at 10^7 particles/cc, neutral drag on the satellite would permit it to orbit for about nine years, Dr. Pearse said.

The authors have emphasized that they make no attempt to estimate accurately an expected lifetime for the satellites, however. As Dr. Pearse points out:

"One of the main purposes of sending up a satellite is to determine the atmospheric parameters which are at present not well known. We expect that this calculation will be useful in determining these parameters."

Columbia Develops Radar

(CONTINUED FROM PAGE 8)

the Doppler effect become proportionally more pronounced the longer the wave is received.

With a target 200 miles away, a pulse signal returns in 0.0024 sec, or 2.4 millisec. Of this interval, 0.0000-024 sec, or 2.4 microsec, is the transmitting time. For a 3000 kc signal, only 7200 cycles constitute one pulse. On the other hand, the ORDIR system would transmit for 167 millisec, or 70,000 times longer than the pulse.

For a target moving at 1000 mph, the Doppler shift causes a 10 kcps rise in the signal frequency. In the pulse echo, the frequency change would be a superabbreviated two-hundredths of one cycle, whereas in the ORDIR signal, the frequency change is magnified 70,000 times. Target velocity, consequently, is correspondingly more precise.

This improvement factor of 70,000 carries through other aspects of the radar's use. With a target 2000 miles away, the power loss factor of 10,000 eats up most of the advantage, so that accuracy at that range increases only several times.

Two conditions make these improvements possible: Frequency modulation that is more linear than ever before achieved, and signal stability 50 to 100 times higher than ever before achieved. An exceptionally long integration time of as much as $^1/_2$ sec is attained—in effect making the signal "stand still" on its return for close scrutiny for the "tagged" waves. Receiver noise thus presents little problem and the ORDIR can work with echoes "far below" the noise level of the instrument

All this was done with conventional components, according to Dr. Bernstein, coordinator for the project. "The trick is in the circuitry. It's not conventional, and it's not an adaptation of existing techniques," he explained. "To my knowledge, it can be accomplished today only by our laboratory."

Such are the contributions of the Columbia scientists. They built an experimental setup that has worked "extremely well," with an efficiency very close to the theoretical limit (above 90 per cent). The receiving unit is located miles away from the transmitter because of its hypersensitivity; there appears to be simpler problems involved in locating the units within hundreds of feet of each other, Dr. Bernstein said.

Firth Sterling Ups Prices On High-Temperature Alloys

Firth Sterling, Inc., has announced a 4 per cent increase on high temperature alloy base prices. The increase followed by a few days the announcement by the company of higher prices on stainless steel extras, which also apply to high temperature alloys. The company produces such high temperature alloys as A-286, 16-25-6, Greek Ascoloy and Discaloy.

Boron Trichloride Now Offered in Tank-Car Lots

Boron trichloride, a raw material used in the manufacture of high energy fuels and until recently available only in limited quantities, is now being produced and sold in tank-car tonnages by Stauffer Chemical Co., which has also announced price reductions on the chemical.

Boron trichloride in 100-lb cylinders has been reduced from \$3 to \$1.70 per lb, with ton cylinders priced at \$1.25 per lb. Tank-car lots are priced on a contract schedule.

Space Medicine TV Series Nears Completion

"Doctors in Space," a series of 13 half-hour educational television programs, is nearing completion at the University of Houston, Tex. The programs written by Green Peyton, head of information services at the AF School of Aviation Medicine at Randolph Field, feature discussions by more than 20 top AF and Navy space medicine and rocket specialists. Financed by the Ford Foundation, the series will be distributed by the National Education Television Center, Ann Arbor, Mich.

IBM Distributing Film On Project Vanguard

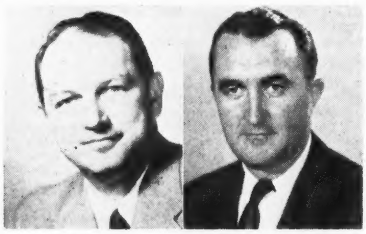
A motion picture on Project Vanguard has been distributed to 225 television stations in 12 countries by International Business Machines Corp. Entitled "A Moon Is Born," the four-minute animated film, available in both color and black-and-white, shows the launching and flight of the Vanguard vehicle, how the earth satellite will be placed in orbit and how the satellite will be tracked.

people in the news

APPOINTMENTS

Leonard Pincus has been elected a vice-president of Airtron Inc., Linden, N. J. Pincus will co-direct the expanded Microwave-Electronics Div., with **Tore N. Anderson** vice-president and director of engineering.

Three major appointments have been made in the reorganized engineering department of Philco's Government and Industrial Div. **James B. Williams** has become director, weapon system engineering; **Herman A. Affel,** director, computer and control engineering; **John Colocousis,** chief mechanical engineer.



Pincus O'Donnell

Charles J. O'Donnell has been chosen general manager of Reconnaissance Systems Div., the largest of Fairchild Camera and Instrument Corp.'s six operating divisions.

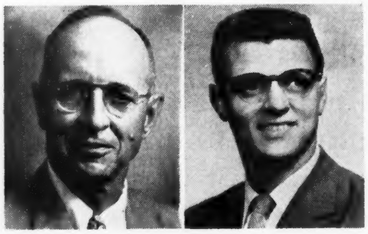
Cornell Aeronautical Laboratory, Inc., has regrouped its echelons, created six new division directors and five new department heads, in a move "to bring more direct effort to technical program supervision and planning."

Under the new organization, the following were appointed division directors: **William F. Milliken,** full-scale; **Franklin K. Moore,** aerodynamic; **Harold A. Cheilek,** engineering sciences; **Robert H. Shatz,** systems research; **Robert S. Kelso,** experimental facilities; **Seville Chapman,** physics.

The new department heads are **Robert A. Wolf,** systems requirements; **David A. Kahn,** systems synthesis; **Maurice M. Kaushagen,** electronics; **Walter P. Targoff,** aeromechanics; **King D. Bird,** transonic tunnel.

John J. Hensel, production and manufacturing costs expert, Piasecki Aircraft Corp., has been upped to administrative coordinator.

Donald B. Otis has become director of planning, Military Products Div. of International Business Machines Corp. **John N. Raines** has been named manager of marketing for the division.



Hindman Moncher

Bernard Levine has been appointed as a member of the technical staff of General Electric's Technical Military Planning Operation, Santa Barbara, Calif. Dr. Levine was supervisor of structures for the Hermes project.

William P. Hindman, works manager of ACF Industries, Inc., Milton, Pa., plant, also becomes vice-president of the newly formed Advanced Products Div.

Roy C. Irick, former project engineer on the Sidewinder at the U. S. Naval Ordnance Laboratory, Corona, Calif., has gone with Pacific Semiconductors Inc., Culver City, as head of applications engineering.

Frank L. Moncher, chief engineer, Airborne Products, Vickers Inc., has been appointed director of engineering of the newly formed Aero Hydraulics Div.

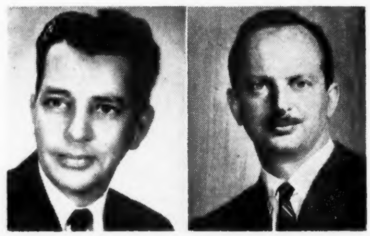
V. F. Simonick has been named chief of the new missile engineering quality assurance group at Douglas Aircraft Co., Inc., Santa Monica Div. He previously was chief of the A-260 hydromechanical section. **H. J. Ide,** hydromechanical assistant supervisor, succeeds Simonick; **J. M. Smith** replaces Ide.

Vogel Gillings

Vernon H. Vogel and **John W. Gillings** have been appointed directors, respectively, of the newly created electronics unit and fluid controls unit, Aeronautical Div. of Robertshaw-Fulton Controls Co. Vogel will head the development of missile and aircraft subsystems. Gillings will superintend research and development in fields of missile ground pressurization units, and similar activities.

Dexter Rosen of Bell Aircraft Corp. becomes administration department manager, Guided Missiles Div., responsible for programming, management control functions, and systems and methods.

New officers of the recently formed Specialized Propulsion and Control Equipment Corp., (SPACE Corp.), Dallas, are **M. G. Hughett,** president; **C. H. Palmer,** executive vice-president; **Ellie Jones,** vice-president of sales; **W. C. Parker,** vice-president of engineering; **M. E. Parker,** vice-president of manufacturing; **James R. Stanley,** treasurer; **Bess Bond,** secretary. **Kenneth W. McCrum** has been named vice-president to direct the development of rocket test facilities. Among his achievements are the design and development of Sonar search equipment and countermeasure devices.



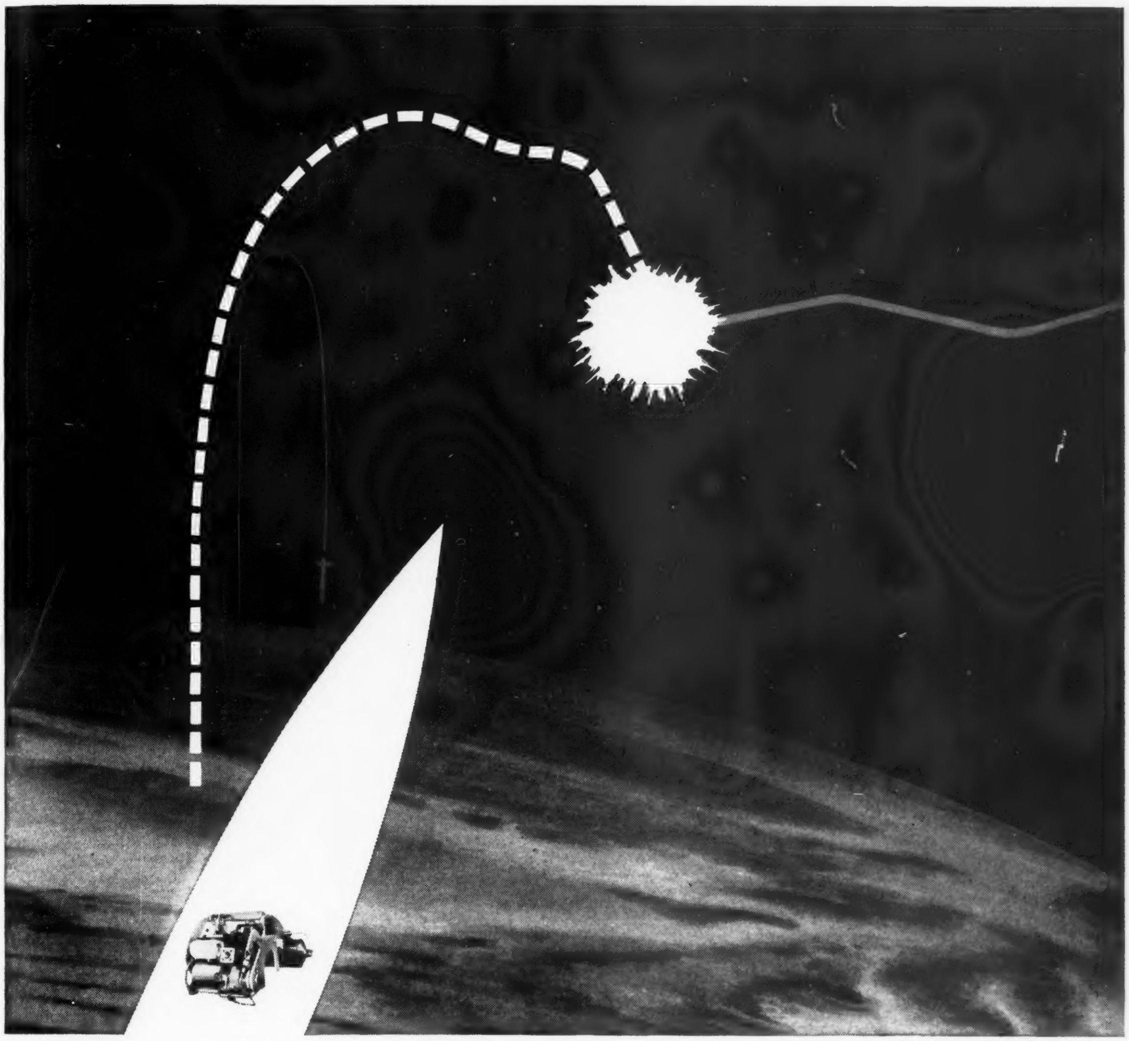
McCrum Wyle

Members of the board of directors are Hughett; Stanley; **D. H. Byrd,** oil operator; **George Rooker,** Metropolitan Dallas Co.; **Sanford C. Miller,** A. C. Allyn & Co., Chicago, investment bankers; **Joseph P. Crosby,** Bear Stearns & Co., New York, investment bankers; **J. Paul Jackson,** attorney, Dallas.

A group of MIT engineers have organized Dynamic Research Corp., Woburn, Mass., exclusively devoted to inertial navigation. They are **John S. Anderegg Jr.,** president; **Howard R. Whitman** and **Malcolm A. Douglas,** vice-presidents; **James P. Andersen,** treasurer.

Thomas E. Walsh, formerly with Ramo-Wooldridge Corp., is now controller of Precision Equipment Co., Torrance, Calif.

Frank S. Wyle heads Wyle Associates, El Segundo, Calif., a new national sales and technical agency specializing in missile and aircraft testing



and test equipment. **Elmer R. Easton** has been appointed general manager. He previously was sales manager, PacAero Engineering Corp.

Whitney Collins has joined Solar Aircraft Co. as executive assistant to president **Herbert Kunzel.** Collins, formerly with Continental Aviation and Engineering Corp., now will engage primarily in long-range planning.

Collins Beck

Chandler C. Ross, vice-president of engineering, Aerojet-General Corp., also becomes vice-president of its Nucleonics subsidiary. **H. W. Davis,** assistant general manager of the subsidiary becomes vice-president and comptroller. **Marshall A. Beck** steps ahead to assistant manager of Aerojet's Architect-Engineer Div.; **Gordon Banerian,** manager, Turbo-Machinery Div., has been appointed to the company's Titan-ICBM technical advisory committee.

Hartwell F. Calcote, former vice-president and director, Research Div. of Experiment Inc., is president and director of research of a new scientific research group, AeroChem Research Laboratories, Inc., Princeton, N. J. **Gosta A. Akerlof,** former research director, Princeton Radiation Chemistry Laboratory, is project director; **Edward O. Ansell,** general manager; **Josef V. Leicht,** a staff member.

Vernon L. Haag, Gray Manufacturing Corp., joins Farnsworth Electronics Co. as vice-president, missile test equipment. He formerly was vice-president of operations, engineering and manufacturing at Gray.

Richard A. Brown, chief of projects, service engineering, Aeronautical Div., Minneapolis-Honeywell Regulator Co., has been named manager, service engineering, for the new inertial guidance plant in St. Petersburg, Fla.

Thomas H. Johnson, director, Research Div., AEC, has resigned his post to become manager of the Research Div. of Raytheon Manufacturing Co.

HONORS

Charles Stark Draper, professor and head of the Astronautical Engineering Dept. and director of the Instrumentation Laboratory, MIT, has been awarded ASME Holley Medal for 1957. Dr. Draper won the medal for his discovery of what is called a revolutionary principle for controlling guns fired from moving platforms at moving targets, cited as a major factor in the successful prosecution of World War II. The medal was last awarded in 1955.

The American Ordnance Association has cited **Robert C. Geffs,** manager of the Contract Div., Clary Corp., for his role in the country's defense and preparedness. He is currently chairman of the board of the Los Angeles post of the association, and previously had been president for five years.

Charles DeWayne Thornton, director of research and assistant to the president on atomic energy, Farnsworth Electronics Co., was recipient of an honorary Doctor of Science degree from Indiana Technical College, Fort Wayne.

DEATHS

Irving Langmuir, Nobel Prize winning scientist, died at the age of 76 from a coronary thrombosis. He was on the staff of General Electric Research Laboratory from 1909 until his retirement in 1950. In 1932, Dr. Langmuir became the first American industrial chemist to be awarded the Nobel Prize, granted him for researches in his new-found surface chemistry.

NACA Tour

The triennial guided tours of the NACA's Lewis Laboratory, Cleveland, by members of the military, aircraft and related industry will be held Oct. 7–11. Visitors, by invitation only, will be shown the new 20,000-lb-thrust static test facility that has just been completed.

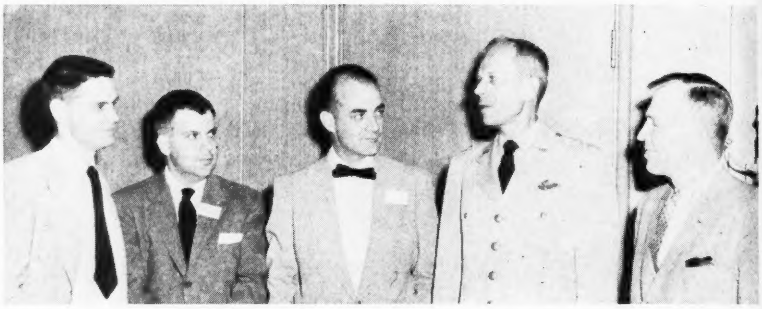
on the calendar

1957	
Oct. 1–5	Aeronautic Meeting, Aircraft Production Forum and Engineering Display, SAE, Los Angeles, Calif.
Oct. 7–9	National Electronics Conference, Chicago, Ill.
Oct. 7–12	**Eighth International Astronautics Congress, International Astronautical Federation, Barcelona, Spain.**
Oct. 10–12	Fuels Conference, ASME, Quebec City, Quebec, Can.
Oct. 21–23	Power Conference, ASME, Allentown, Pa.
Oct. 28–29	East Coast Aeronautics and Navigation Conference, IRE, Baltimore, Md.
Oct. 30–31	Annual Technical Meeting, Electronic Devices Group, IRE, Washington, D. C.
Nov. 6–8	Fuels and Lubricants Meeting, SAE, Cleveland, Ohio.
Nov. 11–13	Instrumentation Conference and Exhibit, IRE, Atlanta, Ga.
Nov. 25–26	Joint Meeting, IAS and Canadian Aeronautical Institute, Montreal, Quebec, Can.
Dec. 1–6	Annual Meeting, ASME, New York, N. Y.
Dec. 2–5	**American Rocket Society 12th Annual Meeting, Hotel Statler, New York, N. Y.**
Dec. 6–7	**American Rocket Society Eastern Regional Student Conference, Hotel Statler, New York, N. Y.**
Dec. 8–11	Annual Meeting, AIChE, Chicago, Ill.
Dec. 17	Wright Brothers Lecture, IAS, Washington, D. C.
Dec. 26–31	Annual Meeting, American Assn. for the Advancement of Science, Indianapolis, Ind.
1958	
Feb. 4–6	Thirteenth Annual Technical and Management Conference, Reinforced Plastics Div., The Society of the Plastics Industry, Inc., Chicago, Ill.
March 16–21	1958 Nuclear Congress, Chicago, Ill.
March 17–20	**American Rocket Society—ASME Aviation Div. Conference, Statler-Hilton Hotel, Dallas, Tex.**
June 3–5	**National Telemetering Conference (under auspices of ARS, IAS, AIEE, ISA), Lord Baltimore Hotel, Baltimore, Md.**
June 9–11	**ARS Semi-Annual Meeting, Hotel Statler, Los Angeles, Calif.**
Sept. 15–18	**ARS "Missile Industry" Meeting, Hotel Statler, Detroit, Mich.**
Dec. 1–5	**ARS 13th Annual Meeting on "The Age of Space Flight," New York, N. Y.**


SNARK
BOMARC
FALCON
MATADOR
PROFILES OF EXPERIENCE
by LIBRASCOPE

ARS news

250 Attend Symposium on Transport Properties



SYMPOSIUM OFFICIALS join Gen. Demler for informal discussion. They are (l to r) ARS President Robert Truax, Ali Cambel, John Fenn, Dean H. B. Gotaas.

THE Second Biennial Gas Dynamics Symposium sponsored by ARS and the Northwestern Technological Institute brought a large group of outstanding specialists to Evanston, Ill., on August 26–28.

Some 250 registrants heard 19 papers presented on a subject of fundamental and substantial interest to the rocket and missile field—the state of knowledge of transport properties such as viscosity, diffusivity and conductivity at extreme conditions.

Key to the importance of the symposium was offered by ARDC Deputy Commander Brig. Gen. Marvin C. Demler, featured speaker at the symposium banquet. Gen. Demler said that "requirements in rocket technology have outstripped our knowledge of phenomena occurring in the rocket engine chamber."

He pointed to high temperature materials and gas dynamics as the two areas where the biggest vacuum of knowledge lay, and where most scientific help was needed. Of the first problem, he said: "We must try to strengthen the very lattice bonds of the materials, and to do this we must explore the basic areas of material sciences." Failure, he added, means the end of the line for chemical propellants.

It was the second problem—control of gas particle movement—which had the most meaning for those in attendance. Here, Gen. Demler dealt with the significant loss of energy in conventional combustion chambers due to random gas flow against the walls. He cited the study of magneto fluid dynamics as a hopeful means of controlling particle flow away from chamber walls.

Several of the symposium papers dealt with aspects of these studies, notably the paper by Marshall Rosenbluth of General Atomic Div., General Dynamics Corp. Rosenbluth covered work he has been doing on collision cross sections of particles in completely ionized gases.

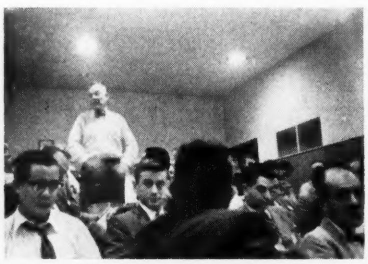
For a review of other papers, see following story.

A Need to Know

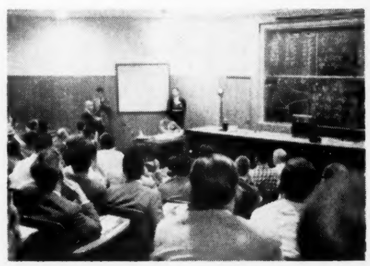
The Northwestern Symposium was a timely one, coming on the heels of recent advances in the combustion, aeronautical, astrophysical and nuclear

Symposium Scenes

Session speaker holds close attention of S. Penner, John Fenn and Michel Boudart (front row).



The hands have it as Richard Folsom tries to put point across in post-session discussion period.



Over-all attendance hit high of about 200 with registrants representing more than 100 different organizations.

Mid-session break gives session chairman Robert Gross opportunity to discuss paper with author.

Author Immanuel Estermann answers audience query. At left are Ali Cambel and Pol Duwez.

Lunchtime discussion proves lighter meal for (l to r) John Tormey, Vivian and Jerry Grey, and James R. Patton.

sciences which have focused attention on the need for an unusually wide variety of basic data on the physical properties of matter.

That the problem is a serious one is indicated by the fact that engineers concerned with combustion, heat transfer problems in rockets, or high speed flight, plasma phenomena, etc., often have difficulty in finding or selecting proper values for transport properties because of the pressure, temperature and state of the gases involved in a particular problem.

Often, verification of recent theoretical developments becomes difficult or impossible because reliable physical data are unavailable. When a new theory incorrectly predicts the result of a high temperature and pressure phenomenon, it is difficult to judge whether or not the physical constants substituted in the theory are really to blame.

While papers presented at the symposium were for the most part reviews of basic material, the fact that all this material was brought together and offered in condensed form at one time and, even more important, that leading authorities in the field were assembled for discussions of basic problems, made the meeting an outstanding one.

Much that was presented at the meeting is worthy of comment, but space forbids any more than a brief review of several typical papers.

The paper by J. O. Hirschfelder, C. F. Curtiss and R. B. Bird of the University of Wisconsin on "Theories of Gas Properties" (468-57) provides a brief survey of material from their book and others, with emphasis on those aspects of the subject which deal with high temperature and high pressure calculations. Certain new theories for dense gases were also briefly mentioned, and are of interest.

J. Kestin of Brown University, in his paper on "Direct Determination of the Viscosity of Gases at High Pressures and Temperatures" (470-57), offered an interesting critical review of the more important methods. His discussion of oscillating-body and falling-body viscometers was also thorough and interesting.

In a paper on "Molecular Beam Applications to Transport Properties in Gases" (476-57), Immanuel Estermann of the Office of Naval Research described the fundamentals of molecular beam methods, their prospects and limitations. The author was not too optimistic about the productivity of such methods in the near future.

S. C. Lin of Avco Research Laboratory, in his paper on "Shock Tube Studies of Transport Properties" (477-57), suggested the indirect method of measuring the stagnation temperature heat transfer rate in a shock tube as a possible means of determining transport properties of high temperature gases. However, since this rate depends on some temperature-averaged transport property through the boundary layer, and there can be severe temperature drops across this layer, this method is limited, and other shock tube experiments must be designed to provide transport data.

Although the paper by S. S. Penner and A. Thomson of Cal Tech on "Determination of Equilibrium Infrared Gas Emissivities from Spectroscopic Data" (483-57) was primarily a review of many of the senior author's publications and presentations, it provided a useful summary of the experimental and theoretical foundations for such work. A correlation of infrared emissivities for water vapor which has not previously appeared in the literature was also presented.

The meeting indicated there was still much to be done in this field, since procedures currently in use which give direct results do not go to high enough temperatures and pressures or do not consider mixtures of gases, and attempts to make indirect measurements leave much to be desired.

However, those in attendance agreed that future meetings of this type, providing an opportunity for those active in the field to get together and talk over mutual problems, can be helpful in finding the answers to some of the basic difficulties.

ONR to Sponsor Classified Session at Annual Meeting

A classified session at the confidential level, on the subject of propellants and combustion, will be a feature of the ARS 12th Annual Meeting in New York December 2–6.

Under the sponsorship of the Office of Naval Research, the session will be in two 90-minute parts.

Chairman of the first part will be Adelbert O. Tischler of Lewis Flight Propulsion Laboratory, NACA, who will deliver a 30-minute keynote and survey paper on liquid rocket combustion. This will be followed by five-minute comments on Tischler's paper by Herbert B. Ellis, Aerojet; Robert S. Levine, Rocketdyne; Kurt Berman, General Electric; Jerry Grey, Princeton University; and Robertson Youngquist, Reaction Motors.

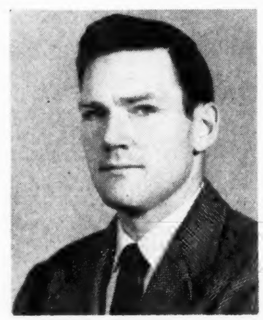
Second half of the session will be under the chairmanship of David Altman of Aeronutronic Systems, Inc. Altman will present a 30-minute keynote and survey paper on liquid rocket propellants. Following this, Paul Winternitz of New York University; John Sloop, Lewis Flight Propulsion Laboratory; Robert Thompson, Rocketdyne; Donald Armstrong, Aerojet; and Thomas Reinhardt, Bell Aircraft, will offer five-minute comments and single out subjects they feel are currently most significant in their fields.

"The primary purpose of the session is to provide ARS with a confidential, capsulated, but highly authoritative, look at the liquid rocket combustion and propellants field in late 1957," says John F. Tormey, chairman of the Propellants and Combustion Committee. Tormey organized the session in cooperation with James R. Patton and Saul Berman of ONR.

Youngquist Is ARS Liaison Rep to ASME

Robertson Youngquist has been appointed by ARS President Robert C. Truax to be the ARS liaison representative to the ASME Board on Technology.

Presently the director of component development at Reaction Motors, Dr. Youngquist has been a member of ARS since 1939. A graduate of MIT, he was editor of the *Journal of the American Rocket Society* from 1949 until 1951.



Robertson Youngquist

The appointment was made pursuant to a recent agreement between the two societies, whereby each would be represented on the other's governing board without a vote.

Craig Named Chairman Of Dallas Meeting

George H. Craig, president of the North Texas Section, has been named ARS chairman for the ASME Aviation Div.-ARS Conference scheduled for March 17–20, 1958, in Dallas.

Craig, senior systems installation engineer at Convair, Fort Worth, was named by Kurt Stehling, national pro-

gram chairman. One of the founders of North Texas Section, Craig attended Texas Christian University and has been with Convair since 1946.

Those wishing to submit papers for the conference should send them to the

George H. Craig

Program Chairman, American Rocket Society, 500 Fifth Ave., New York 36, N. Y., before December 1.

At the same time, Stehling announced that the following ARS sessions are tentatively scheduled for the meeting:

Solid Rocket Installations, Liquid Rocket Installations, Ramjet Installations, Space Flight, Human Factors, Flight Test Instrumentation, Nuclear Propulsion, and New Materials and Processes.

SECTION NOTES

Holloman: Those attending a recent meeting of the special series devoted to important aspects of the exploration of the third dimension and to the conquest of space heard John D. Strong, professor of experimental physics, The Johns Hopkins University, enumerate the tremendous advantages to be gained by lofting complex astronomical equipment to the upper reaches of the atmosphere. The lofting is being effected by polyethylene vehicles.

Dr. Strong's topic proposals were of particular interest to local ARS members because of the obvious relationships to the HADC Balloon Branch, to the high altitude work of the HADC Space Biology Laboratory, and to the balloon design, manufacture and aerial research of Section-member Otto C. Winzen, head of Winzen Research, Inc., of Minneapolis.

New Mexico-West Texas: An interesting talk on "Launching the Satellite," illustrated with slides, was given by J. W. Townsend, director of the Naval Research Laboratory, at the New Mexico A&M College. Dr. Townsend, in charge of the Aerobee program including the launching of the space satellite later this year, also discussed our chances in the race toward outer space.

The previous week, Frank Back, inventor of the Zoomar lens used in radio and TV, was the guest speaker at a joint meeting of the Section and the Las Cruces Astronomical Society held at the college.

Sacramento: The first summer field trip held at Travis AFB and the adjacent Army installations of Nike batteries was a huge success. Over 75 enthusiastic members and their wives and guests attended. They were permitted to examine in detail the B-36, C-97, C-124 and F-102, assisted by Maj. Wilder and individual plane crews who explained and operated the special equipment. At the Nike launcher site, under the direction of Lt. Col. K. D. Goldblum, missiles were raised to simulated firing positions, then restored in the underground magazines. The visitors inspected the radar control equipment for the system. Other similar tours are being planned because of this initial success.

Papers Invited for 1958 Meetings

Kurt Stehling, National Program Chairman, has announced the schedule of national meetings for 1958, along with deadlines for sending in abstracts of papers to be considered by the Technical Committees.

Abstracts should be sent to Program Chairman, American Rocket Society, 500 Fifth Avenue, New York 36, N. Y. They will be forwarded to the appropriate Technical Committee Chairmen for review.

Meetings, along with deadlines for papers, are as follows:

Date	Meeting	Deadline for Abstracts
March 17–20	ASME Aviation Division-ARS Conference, Statler-Hilton Hotel, Dallas, Tex.	Was Oct. 1. Complete MS's due Dec. 1, 1957
June 3–5	National Telemetering Conference (under auspices of ARS, IAS, AIEE, ISA), Lord Baltimore Hotel, Baltimore, Md.	Jan. 6, 1958
June 9–11	ARS Semi-Annual Meeting, Hotel Statler, Los Angeles, Calif.	Dec. 2, 1957
Sept. 15–18	ARS "Missile Industry" Meeting, Hotel Statler, Detroit, Mich.	March 17, 1958
Dec. 1–5	ARS 13th Annual Meeting on "The Age of Space Flight," New York, N. Y.	June 2, 1958

IGY Panel Discussion

(CONTINUED FROM PAGE 23)

Newell: I'm inclined to think there isn't too much to worry about, as far as interference is concerned. From the point of view of transmission, I think you can consider it essentially as empty space.

Haber: There are lots of difficulties, but I think we might have a satellite around Mars in 1982.

Rosen: Well, if we do, it will probably require some form of nuclear power. Chemical energy looks dubious for interplanetary flight.

Haber: Yes, this is true. Again, to get back to man in space, I can see a use for man in this Vanguard project for Mars. Let's say our payload in 1982 might be 1000 lb. Then, by shooting repeatedly, we can accumulate with, let's say, 10 shots, the equivalent of 10,000 lb in space. To integrate that might require a man, you see. Then you can eventually build up something pretty fancy up there—not necessarily inhabited, but something that can, in turn, launch something to go to Mars. There's no doubt about the difficulties involved in getting things together in space, but if you have a man, you can build a fairly large, extremely operative station up there.

DeNike: Well, when we say we may try to put a satellite around Mars in 1982, we're supposing we'll have a pretty accurate navigation system by that time, one that is working all the way. Then maybe you could say this system could be used to put all these payloads in a group where they could be put together. This is the problem which is bothering me—trying to get all the material in one small area where it could be assembled.

The way it is right now it's a difficult enough problem to navigate to a particular spot right here on earth. To navigate to a position in space or into orbits in space which are compatible with this assembly idea raises another tremendous problem.

I would guess that, to carry out this Mars operation, we could more easily build a big enough rocket to achieve it right here—again looking through cloudy glasses, perhaps—than we could solve the navigation problem.

Rosen: I think we'll make more advances in power and in the ability to perform difficult navigational tasks than we will in putting a man up there to coordinate the job in an alien environment.

For instance, if you talk about putting 10,000 lb in space, it might be easier to assemble the 10,000 lb down here and shoot it up in one piece.

DeNike: I'm of that opinion myself.

Rosen: If it's difficult to maintain a man in space, then it is also going to be difficult for him to do any jobs up there.

Haber: Let me say this. I have put a time limitation on manned space flight. I mentioned something like 15 to 30 hours. This is entirely possible, because it automatically eliminates a number of problems and because the flight becomes a mission as we know it today. Given a 1000-lb payload and 25 years, I would say man would be capable of carrying out such a mission. And when I said servicing, I didn't perhaps mean so much as changing a radio tube as I did performing jobs that a man can do better than a machine.

Newell: In 15 to 30 hours we won't be able to do very much. I know that, in working out in the open in cold weather at Fort Churchill, one finds it takes hours to do things that would be a matter of only five or 10 minutes in the laboratory. I would think the same situation would exist in space.

Rosen: Don't you think there might be an attempt to put a man in space just for the sake of doing it, rather than to use him as an adjunct to geophysical experimentation?

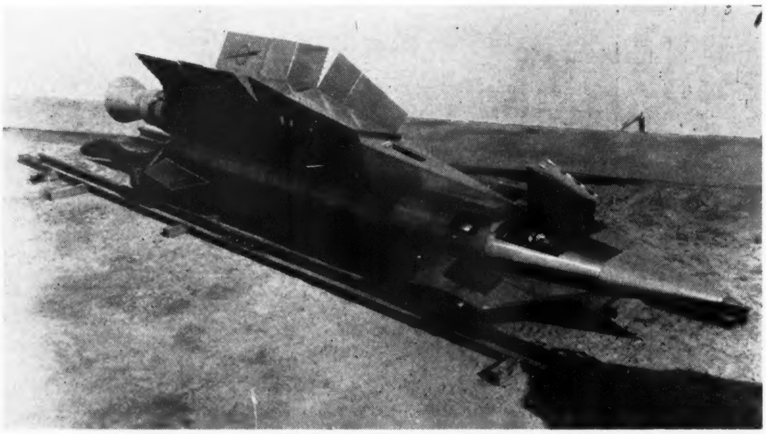
Haber: Possibly, but when the excitement of the first one wears off, you'll find some use for him.

Newell: Isn't the study of Mars a pertinent point here? With all the equipment we have, human visual observation is still the best. So again, if you want to get the ultimate in observation, you still may have to put a man up there to do things that instruments cannot do.

Haber: However, if you take into account electromagnification and some of the other projects that are now being worked on, the picture may change. Here again I think the future may produce some fantastic equipment that we can't even visualize today.

Bush: I'd like to get back to navigation for a moment. A considerable amount of work has been done on celestial controls for rockets. This method of navigation is considered fairly successful at this stage. It seems feasible that by 1982 such a system, with the aid of a data handling system—a computer—should be able to navigate a vehicle to Mars or to an orbit around Mars.

DeNike: The trouble is that, when you're playing around with the tremendous velocities needed to get a vehicle to Mars, let's say, in a reasonable period of time, such as the time limitation we would have to put



1000 mph Sled

This multipurpose lox-alcohol sled, made by Century Engineers, Inc., for the Edwards AFB supersonic track, reportedly has met the following design specifications: Speed in excess of 1000 mph, higher thrust at lower cost than a solid rocket engine, provisions for externally mounting test specimens, and ability to act as a "pusher" sled to impart boost to other rocket sleds. A North American Aviation engine provides 50,000-lb thrust.

MAGNETIC TAPE APPLICATIONS BY AMPEX

8

ONE OF A SERIES

How magnetic tape converts blueprints to parts

From numbers to metal without templates or models

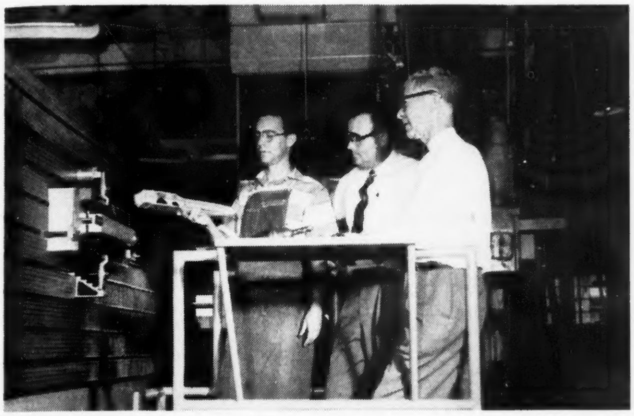


Photo Courtesy of Lockheed Aircraft Corporation

This part was made with "production tooling" that cost less than conventional machining on a single sample. The "tooling" was a reel of magnetic tape programmed from blueprints by computer and electronic director. In a kind of machine-shop black magic, the part sprang into being on a Giddings and Lewis Numerically Controlled Milling Machine. Much larger parts are also similarly made on this same mill.

NOW AT WORK IN ACTUAL PRODUCTION

This is not just a futuristic experiment. A commercial version has been delivered to a number of manufacturers. The first, at Lockheed Aircraft Corporation, produced 96 different complex parts in its second month of operation. Lockheed is using the tape-controlled mill to improve tolerances, eliminate human error and cut machining costs – often by over 50% ($21.32 versus $69.50 per part on one item). It is used for cams, templates and other intricate tooling – also for production parts on Lockheed's supersonic F-104 "Starfighter."

From initial experience at Lockheed, tape-controlled machining shows promise of reducing lead time from drawing board to production of parts by 60 to 70 percent. Since the "complete sets of tooling" are reels of tape, they can be stored as neatly as a row of books. Additional production runs can be made with a minimum of setup.

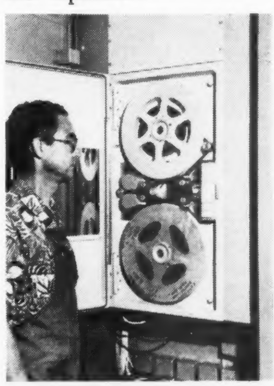
Earlier, at the Giddings and Lewis factory, tape-controlled milling was used to make one-of-a-kind cams and templates for tracer-controlled machines. Cost on a competitive bid basis was less than 50% of that for same work by conventional means. Ironically, this intricate tooling is what numerical control will eliminate wherever it supplants tracer-controlled machines.

A SIMPLE WAY TO HANDLE A MILLION COMMANDS

For the numerically controlled mill, magnetic tape provides 200 commands per second, each defining exact tool positions in three linear coordinates (angular coordinates too, on some). A minimum signal commands only 0.000125 inch of tool motion. One reel of tape programs up to 1½ hours of machine time.

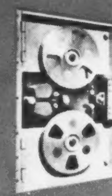
These closely spaced commands are ideal for a self-correcting system of servo controls. Also they eliminate need for expensive computing and interpolating equipment at the individual machine. Centralized programming can make tapes for many machines and is not tied to the time-consuming repetitions of actual production.

With its fourteen tracks, a one-inch magnetic tape has ample reserve for extra functions. Six are used for tool-position coordinates. The others control start, stop, coolant, and even voice instructions for impending tool change. Tracks can even be shared by several functions, allowing still further expansion.

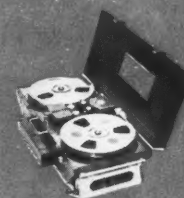


Control tape on an Ampex FR-100 can hold over 1 million commands for each axis of tool movement

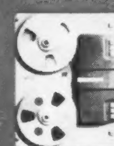
We will be glad to furnish more facts on magnetic tape recording and its use in machine tool control. Write Dept. AA-8.



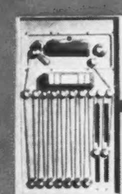
Series FR-100



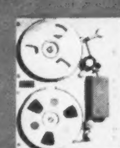
Series 800 Mobile and Airborne



Model FR-200 Digital



Series FL-100 Loop Recorders



Series FR-1100

INSTRUMENTATION DIVISION

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on some sort of auxiliary power unit to compile data when we get there, you're dealing with some pretty high velocities. Consequently, extremely small errors could mean you would miss your target by tremendous margins. We're now in a whole new regime of navigation, and we're just beginning to solve some of these problems on earth.

Rosen: Navigation to Mars by automatic means could be difficult even in 1982. There are so many functions to perform, and the solution is not just more payload. You may need the integrating ability of man to do the job.

Newell: Are you worrying about sensitivity, as well as payload?

Rosen: Not the sensitivity, but complexity. It seems to me that you could navigate to Mars a lot more readily with a man in the vehicle than by automatic means. For one thing, he could make continuous corrections.

DeNike: That's the key. Continuous correction would put a minimum burden on the propulsion system.

Rosen: Right. Also it reduces the requirements for extreme accuracy, which mean weight in the guidance system, and for storage of information.

Bush: That was primarily the reason I felt some kind of computing system would be necessary along with a built-in navigation system. This would permit continuous space position observation and continuous correction—within limits, of course.

DeNike: I'm still worried about the sensitivity. I keep remembering our present satellite program, which is the background for this discussion. I think we've already announced the altitude limits we're shooting for, and we all know the difficulties involved in getting an object up to a point which is so close. Now we're talking about stretching this out to the distance to Mars.

Haber: Let me say this, Mr. DeNike, perhaps we might not be so ambitious. Perhaps when I talk of a Mars satellite in 1982 I'm overreaching myself quite a bit. However, it will be something if we can get as close as a million miles and photograph Mars and then bring the vehicle back.

Newell: That's better.

DeNike: That's much better.

Rosen: I will agree that the first attempt, and early attempts, at space flight will be robot attempts. However, I'd like to point out that the reason we're agreed on this, Dr. Haber, is because of the way you scared us about putting a man up there.

Haber: Let me say that I really did not want to scare anyone by looking at manned space flight in terms of practicability. I don't doubt that it can be done, at least for a limited period of time. However, whether it is practical or not still remains to be decided.

To sum up, I myself lean toward robots and instrumentation for some time to come before I see a spot where man, with his great powers of integration, will be able to do things that a robot alone could not do.

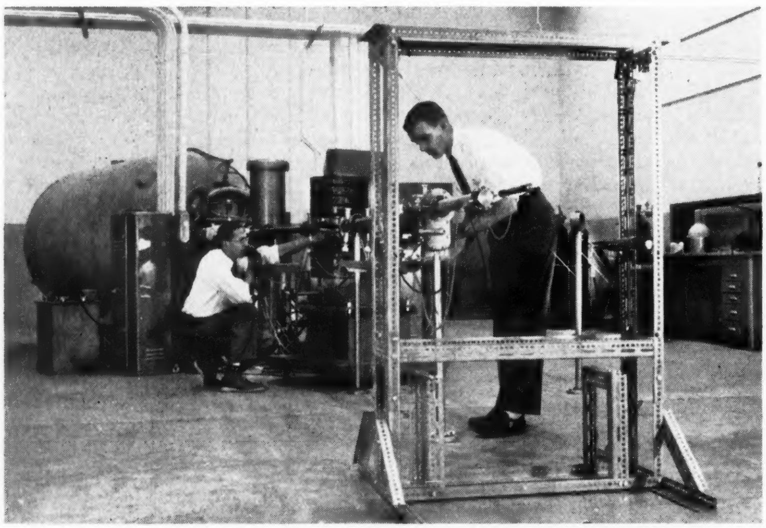
DeNike: You forgot to mention that instruments are a lot easier to get back, too. In fact, man is about the most fragile cargo to recover that I can think of.

Newell: I'd like to make a comment along these lines myself. The way I look at it is this: When you start out on a project like this, you can do two things by using a robot. First, you can perform some experiments in which you know the chances for success are less than unity. You could be satisfied if you knew it was 90 per cent, or something like that. Second, you can use these experiments to learn more about what man is going to have to do when you finally send him up there.

DeNike: I think that has been very well said.

Haber: I'd like to add one final comment, just to put this discussion in the right light.

Nuclear Propulsion for Missiles



Scientists set up experiment with Lockheed's new Van de Graaf ion accelerator.

Nuclear propulsion of missiles is under serious investigation by Lockheed Missile Systems Div. scientists, it was recently announced. Helping in the study is a new 3-million volt Van de Graaf ion accelerator, said to be the largest unit of its type in the aircraft industry.

The atom smasher is located at the company's nuclear lab, one of the facilities of the division's research and development center at Stanford University in Palo Alto. It is the first instrument of its kind on the West Coast, and will be available to nearby scientific groups on a commercial basis.

High velocity hydrogen and helium nuclei will be shot from the accelerator in beams. On striking the atoms in a target material, fundamental changes in both the ions and the target atoms will take place. These will be carefully scrutinized for information that may contribute to missiles of the future. Among the fields to be studied are nuclear structure, reactor design, radiation shielding design, and material damage, the company said.

The accelerator is housed in a 2500 sq ft room whose walls of concrete are 3 ft thick. Under the target is a large pit to prevent neutrons from bouncing off the floor to interfere with measurements. Standard radiation safeguards protect the personnel operating the instrument.

Let me take you all back 25 years. I think if you had been asked then if you thought you could build a rocket and guide a satellite into an orbit around the earth with even a 50 per cent expectation of success, you would have said it was utterly fantastic.

With another 25 years to go before 1982, who can tell?

Hersey: I think that's a good note to end on. Thank you very much, gentlemen, for this thought-provoking discussion of IGY 1982–1983.

While much of the scientific research in the next 25 years will be done along conventional lines, it is clear from this discussion that we all believe the most spectacular effort in IGY 1982–1983 will involve extraterrestrial rocket flights. In addition, greater numbers of close-range satellites, larger and heavier satellites, more sophisticated instrumentation and more elaborate physical experiments are foreseeable.

Obviously, the extent to which these possibilities materialize will depend on the progress we make during the next 25 years in such areas as propulsion, guidance and communications.

It will make interesting historical reading in 1982, I think, to look back on this discussion and see how much or how little courage we had in our speculations.

Spawning Ground

(CONTINUED FROM PAGE 43)

ing of these scientific tadpoles, the company employed Jack Rudner, assistant principal at one of the high schools, to act as training coordinator. Rudner, a former science teacher, was available at all times to answer questions worrying either the students or Airborne personnel.

Friday morning group discussion periods, during which the students reported on their week's work, and biweekly reports by their immediate supervisors, enabled the company to keep close tabs on the boys' progress. Copies of these reports were also sent to their parents in order to further coordination between the school, the company and the home.

All in all, says Airborne, the program worked out rather well. Next summer the company plans to add new students to the program, and also to take on those students from this year's session who have turned 18 as regular summer employees. In addition, Airborne hopes to keep tabs on each of its science apprentices for the next few years to see how they make out in their chosen fields.

By catching these youths in what are perhaps their most formative years and giving them a taste of the professional scientist's daily fare, Airborne aims to accomplish two things. Primarily, it hopes to encourage those with the right kind of talent, interest and aptitudes to choose careers in science and engineering. At the same time, and almost as important, it hopes the program will weed out those who do not have a true feeling for work of this type.

If such a program were adopted on a national scale by enough other industrial firms, Airborne believes it would help relieve the shortage of scientists, mathematicians and engineers that is foreseen in the next five to 10 years.

Evaluating the full benefits of this first small-scale attempt to persuade youngsters to take up scientific careers will undoubtedly take time. But right now everyone connected with the program is more than satisfied with the outcome of this summer's program, small-scale though it was, and is looking forward to its continuance.

American Potash Offers Two New Oxidants

American Potash & Chemical Corp. is now in production on two new lithium compounds—lithium perchlorate and lithium nitrate—for use in high energy fuel applications. Both are oxidants for solid propellants and both have a high oxygen content on a weight basis, amounting to about 60 per cent in lithium perchlorate and almost 70 per cent in lithium nitrate.

Area Rule Application For Jet Transport Designs

Cruise speed of future jet transports may be increased by as much as 50 mph, by application of the area rule into the 550–600 mph speed range, the NACA announced.

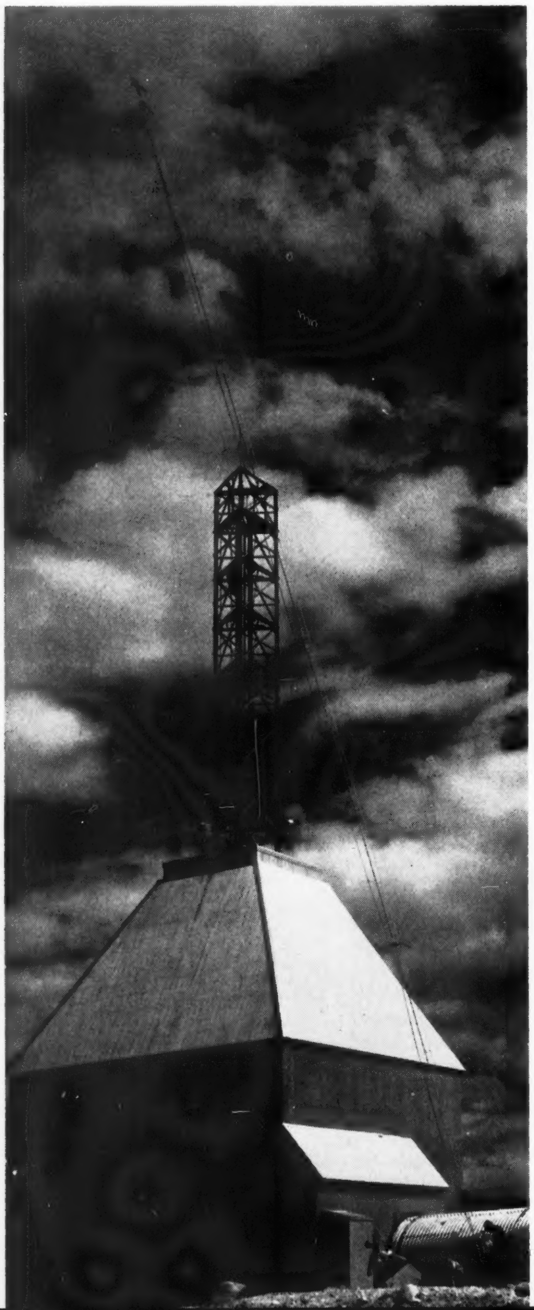
The development of the area rule concept to make it useful at such speeds has been in progress at NACA's Langley Aeronautical Laboratory. The large and rapid compressibility "drag rise" which occurs when a transport plane flies faster than Mach 0.8 (about 550 mph at 30,000) has been long known. The area rule extension seeks to provide a delay in this compressibility drag rise by redistribution of the cross-section area of the fuselage and the wings.

Present experimental work is being conducted by the same group, under Richard T. Whitcomb, that made the area rule discovery and development in 1951–1952.

Arctic tower

AS LAUNCHERS go, the enclosed, stovepipe-like structure devised by Aerojet-General Corp. for firing sounding rockets from Fort Churchill, Canada, is a strange device. But launching rockets in the sub-Arctic can be a finger-freezing operation; and missile men, like safe crackers, don't like to wear gloves.

So, faced with the problem of subzero launching temperatures, Aerojet set about to develop an enclosed launcher. The result was a steel frame structure covered with metal sheathing. Boxlike at the base, the building has four sides that first rise vertically, then, trying to form a roof, slant toward an apex. Just short of the juncture, the four slanted sides are aborted, leaving a square hole. Into this opening is inserted a square, metal-latticed tower.



Over-all, the main building is 40 ft square and about 56 ft high (approximately five stories). Projecting above the building is the chimney-like tower that guides the rocket on its first few faltering steps. Inside the main building are metal stairways and galleries which afford the missile men complete access for inspection, adjustment and fueling.

The tower actually goes through the entire structure and comes to rest on a turntable pad at the base. The turntable permits the tower to be revolved at will and sloped as required—to counteract wind velocity and direction—to angles up to 10 deg in any direction. At the point that the tower enters the base housing is a gimballing ring. A nylon tent is loosely fitted to the opening at this juncture to keep out the cold while permitting the tower to swivel freely.

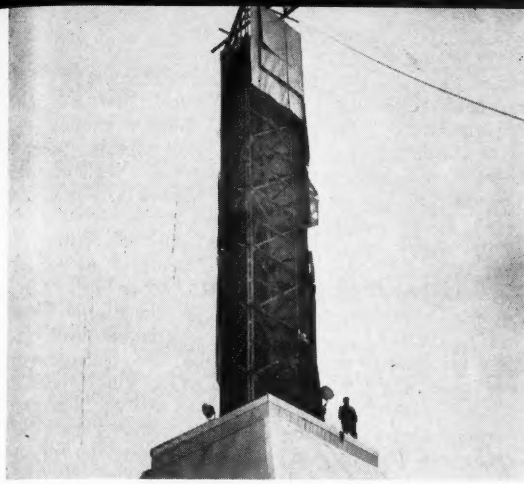
At the base of the launching structure are the blast doors, metal panels that are raised just prior to firing in order to permit the tremendous pressures built up on the ignition of the rocket to escape. After firing, these panels drop down to reform the lower walls of the launcher.

The rocket, placed on a transport dolly, enters the launcher from a nearby checkout and assembly area through a connecting tunnel. When the dolly is in position, the rocket and the rail upon which it is resting are raised vertically, the rail forming the third track of the launcher. The rocket is now in position, ready for a vertical checkout and firing.

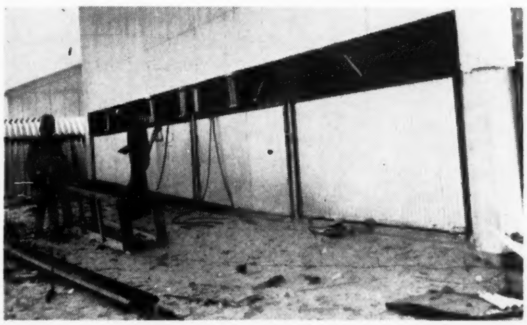
In pre-IGY firings last October and November (see Jet Propulsion, Jan. 1957, p. 52), experimenters found that booster blast pressure from repeated firings was spreading the metal sheathing on the launching tower. Then, on November 8, a rocket exploded while being held at X-minus-15 min, damaging the launching structure. The tower was repaired, and on November 11 a Signal Corps grenade rocket was successfully fired but blew the sheets off the launcher. Repairing the tower this time, the engineers decided to leave the metal sheathing off the projecting "chimney" to reduce blast damage. They also modified the blast doors.

The remaining three pre-IGY rockets left the tower without incidence and no tower trouble has been encountered from the IGY rockets already fired from Fort Churchill this year, nor is any expected from those remaining.

UNLIKE OTHER LAUNCHERS, Fort Churchill structure is enclosed to protect personnel against extremely cold weather.



SHEATHING is completely removed from tower after early rockets blew off many metal panels.



WORKMEN modify blast doors to relieve rapid pressure build-up from rocket booster.

INSIDE LAUNCHER, odd geometrical pattern is presented in view from bottom up, showing square tower opening, gimbal ring, odd-shaped access platforms, vertical ladders, and slanting roof.

Capital Wire

(CONTINUED FROM PAGE 10)

effort on improved, solid propellant missile of Redstone class.

• Acquisition of real estate for ICBM bases is being delayed pending basic decisions on type and location. AF would like to have them away from coasts—perhaps behind mountain ranges—and is exploring various design possibilities. Meanwhile, work proceeds on equipment like trailer-truck that carries Atlas to Patrick AFB, and ground handling techniques are being studied at Camp Cook, Calif.

IGY

• Seven countries have accepted invitations to an international conference on rocket and earth satellite programs for the IGY. First major IGY meeting to be held in this country, it will take place in Washington Sept. 30–Oct. 5 with the National Academy of Sciences as host. Tentative agenda calls for discussion of the ground station tracking and observation program, communications problems, interchange of data from rocket and satellite experiments, and a general discussion of scientific work connected with the IGY firings. Of major interest will be what Soviet scientists have to say about their satellite.

MANAGEMENT

• Pressure for tighter coordination of missile projects, possibly in a special agency like that which developed the atomic bomb, is an almost certain aftermath of the news splash made by the Soviet ICBM. Unless the Administration lifts the secrecy curtain to reveal substantial progress on U. S. ballistic missiles, Congress is likely to order extensive hearings on the management of the program.

Pentagon will resist violently any drastic change in the present organization of missile research, development and production. But a number of Congressmen, worried by reports of Soviet progress, and irked by the continuing and virulent rivalry between the Army and Air Force, think the matter needs a close looking-over.

NEWS

• Pressure on Pentagon to release more information on U. S. missiles is mounting. Noting ambiguity of Soviet ICBM announcement, several top defense officials pointed out that President Eisenhower could have issued a similar statement—vague but psychologically powerful—last autumn when the Army lobbed a multistage test vehicle over 3000 miles from Cape Canaveral.

Question is being asked: Is psychological initiative and opportunity to engage in "ballistic blackmail" being sacrificed to the Communists simply to maintain dubious advantages of super-secrecy on U. S. developments? A number of military men think the answer is yes, are getting support from some diplomats and members of Congress.

• Pentagon meanwhile shows some signs of easing blackout of missile test information. A press tour of Patrick AFB is likely sometime this year, with firing of a Redstone as highlight of the show.

The Martin Team

(CONTINUED FROM PAGE 33)

space a small satellite that will live on for months or possibly years.

An almost unbelievable event! But of all the thousands of words that have been written and spoken about the forthcoming launching of this first artificial moon around the earth, most of them have ignored the human factor. What are these men like? Are they the eccentric longhairs pictured by many science-fiction writers and weird movies? How are they organized? Who provides the spark? Who presses the button? What is the tension like among the rocket men before a shoot? Here in a close look at the men, their background and their work, are some of the answers.

Accent on Youth

Despite its phenomenal growth in the past few years, rocketry is still a young science and a young man's field. Wernher von Braun was still in his twenties when he went to Peenemunde to work on the V-2 project during World War II. After the war, when the U. S. Naval Research Laboratory was looking for an aircraft company that would design and build the Viking high altitude rocket, they chose Martin because its engineers were both young and eager. And with the Viking, American rocketeers came of age.

Martin's key man on the Project is N. Elliott Felt Jr., aged 32, who is Vanguard operations manager. Felt worked on perfecting the complex electrical mechanisms and autopilot system of the Viking. In this capacity, he showed his ability as a good organizer, trouble shooter, administrator and electrical engineering expert. He possesses a Bachelor's degree in Engineering from the University of Maryland and a Master's from Georgia Tech, where he specialized in electronics and servomechanisms. His Master's thesis, "A Mechanism for Continuously Computing the Ratio of the Ordinates of Two Curves," was, in his own words, "distinguished mainly by the length of the title."

Of Welsh stock, Felt has an excellent sense of humor. He got his start as a newsboy in his home town of Philadelphia, Pa. For several years now, he has been an enthusiastic rocketeer. He is the proud father of a young boy and girl.

Felt's right arm and one of the key men on the project, Donald J. Markarian, project engineer, is also just 32 years old (a few months younger than his boss). He served in the U. S. Army Air Corps during World War II. A native New Yorker, he is married and has two young daughters.

Markarian is the chief supervisor of some 220 engineers, who are mainly responsible for seeing that the launching vehicle and all of its components, including the satellite and the three rocket motors, are designed to perfection. An engineering mistake can be costly, both from a dollar standpoint and from a prestige standpoint. He previously worked on fighter aircraft, seaplanes such as the four-jet Seamaster and the Matador, our first tactical surface-to-surface missile.

APE's Play Vital Role

In his present job, he is assisted by a "bunch of APE's" as they are called around the plant. These APE's (assistant project engineers) help their boss in supervising, directing and controlling the entire engineering effort on the Vanguard vehicle. The APE's have charge of such important functions as that of flight dynamics, propulsion, flight path control, product design and structures. Most of these men, like their superiors, are also in their early thirties.

An exception, Bob Schlechter, just over the magic youthful rocket age barrier (he is 41), is the head of field tests. In his job as field project engineer, Schlecter supervises test program scheduling and execution at Cape Canaveral, Fla., where the Vanguard test vehicles and the first earth satellite rocket vehicles will be launched. A key man in the successful Viking firings, he reports to the Naval Research Laboratory field test group.

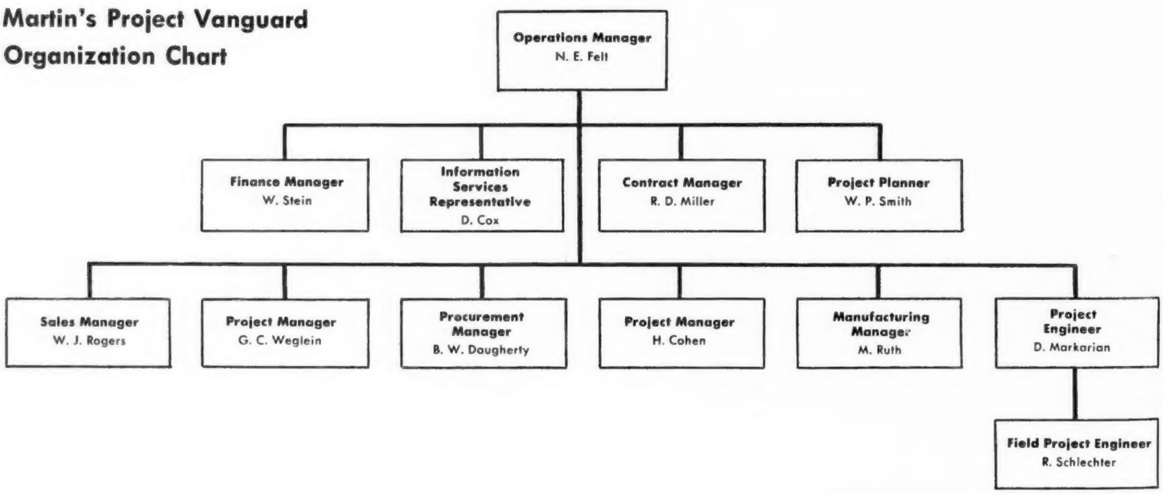
Pushing the Button

When the button is pushed to set off the first "live" satellite launching vehicle, one of Schlechter's men, Paul Karpiscak will push it. Schlechter, his field crew and Karpiscak, in cooperation with the Navy, will have the final responsibility of making sure that the engineer's dreams and plans and the hardware results of those dreams, fabricated 1000 miles away in Baltimore, are brought to a satisfactory fruition.

Paul Karpiscak, 24, who will undoubtedly press the button, is three years younger than Lindbergh when he made his epic flight 30 years ago. The lone Eagle's ordeal lasted over 33 hours. Karpiscak's will last no more than 10 minutes after he fires the rocket.

Karpiscak is a graduate of Purdue, where he earned a B.S. in physics (class of '54). To understand more fully the type of background needed in order to assume the responsibility of a rocket "button pusher," a quick

Martin's Project Vanguard Organization Chart



review of Paul's specialties in college are in order. While at Purdue, he pursued courses in optics, atomic and nuclear physics, x-ray technology, electromagnetic theory, electrical engineering, physical geology, mechanics and chemistry.

Upon graduation, he went to work as an instrumentation engineer at Pratt and Whitney before coming to work for Martin. In March 1956, he was promoted to the position of a Martin engineer, as the result of his giving considerable aid in the design and analysis of the first-stage Vanguard fuel tankage and in solving the problem of liquid oxygen boiling off during flight.

In October 1956 he was assigned as temporary (now permanent) propulsion representative to the field crew at Patrick AFB, where he assumed the duties of acting propulsion head as well as general supervisor of the launch area testing. He pressed the button which successfully launched Test Vehicle 0 on Dec. 8, 1956, and T. V. 1 in May 1957. In his capacity as firing panel operator in the blockhouse control room, he holds the life of each successive test vehicle and the first satellite launch vehicle literally in his fingertips.

No Place for Poor Work

Another member of the top Vanguard team is "Guy" Cohen, who is the quality control manager. This intense and conscientious engineer checks and evaluates all the procured items which come in from over 10 major subcontractors and 150 smaller vendors and suppliers. He also keeps tabs on the over-all efficiency of Martin's part as the prime contractor putting the final vehicle together. Where tolerances have to be very close and reliability high in most cases, his jack-of-all-trades job is an important and taxing one. A native of Baltimore, he spent more than three years as a radio operator and gunner with the U. S. Eighth Air Force.

The manufacturing manager is a good-looking, youthful fellow named Mel Ruth who has worked for Martin more than 15 years. Father of five young children, he finds time to coach a Little League Baseball team.

Ruth is construction boss of the six Vanguard test vehicles as well as of the six actual satellite launching vehicles. His job, often a frustrating one, is translating engineering blueprints into hundreds of metal and electronic parts.

Working within a tight schedule, Ruth is often plagued by engineers who have improved their designs, necessitating changes in blueprints and substitution of parts. Although

these continuing changes help insure better launchings, they cause headaches for Ruth and his cohorts on the assembly line, particularly after construction has started on the vehicles.

When delays in meeting deadlines occur as a result of these changes, minor flareups between the engineers and manufacturing people often result. But ruffled feelings and production rough spots are usually smoothed over at the Tuesday morning Vanguard staff meetings under the direction of Elliott Felt.

Another member of the team with a rough job is Brian Daugherty, a 30-year-old Kentucky-born lawyer, who handles the difficult problems of purchasing and procurement. Working under one of the tightest schedules in American industry and trying to obtain hundreds of new items that will fit into the complex rocket with perfection, like pieces of a jigsaw puzzle, is his primary task. Daugherty is a jovial ex-Marine, who formerly served as an attorney advisor with the U. S. Air Force.

In this position, he works closely with Ray Miller, the contracts manager, who is in his early forties. Miller administers the contract with the Navy, initiating and coordinating actions to insure that Martin's obligations are fulfilled and that the company is properly compensated for its services. He is the precise, scholarly member of the team.

Among the other important members of the team is Walt Stein, the finance manager. Stein handles all the money details and lets the rest of the team know when they are exceeding their budgets which, in this period of a nation-wide economy wave, is quite often.

Planning for the Future

The sales manager on the project is "Jack" Rogers, a graduate of Annapolis and an ex-Navy Commander who commanded a PBM squadron during the Bikini atom bomb tests, as well as a seaplane detachment in the 1947 U. S. Antarctic expedition. Rogers provides liaison relationships with the Navy, the IGY Committee and others, with an eye to what will happen after the IGY is over, as far as the extension of the Vanguard Earth Satellite Project is concerned.

Also concerned with future plans is Harry Sohn. From Martin's advanced design section, Sohn has just joined the project. His job is planning future, post-IGY uses of the three-stage rocket, with particular emphasis on more sophisticated types of satellites.

This writer, in charge of information services on the Vanguard, works with all of the team members in helping to communicate their accomplishments to the public and tries to answer the public's many different queries about the project.

Older Hands Help

Although most of the Vanguard team is composed of young men, there are a few older men who serve an important role as counselors on the project. One who comes to mind first among this smaller group is Paul Smith, manager of operations planning, the last member of the team. Smith is another man who is always in the middle of some knotty problem holding up production or firings, whether they are engine problems, or plumbing, or fuel tank bottlenecks.

Known as Felt's chief henchman and the project's anchor man, he constantly reminds the more youthful team members of delays in delivery of important component parts and their impact on the over-all program. His advice generally strikes some sensitive nerve but is usually accepted. Like the High Lama in "Lost Horizon," Smith is able to give sage advice where needed and to help expedite and correct sore spots, based on his long rocket experience.

One example of his ingenuity concerns a special steel spring which was designed to close an electrical access door in the Viking. When Smith took a look at the original engineering drawing for this new spring, he wondered if it was worth while to tool up to meet this requirement. With all the paper work, supervision and overhead figured in to produce a dozen of these gadgets (one for each Viking) he figured that the cost of these springs could easily mount to $10 each.

So he went across the street from the plant to a local hardware store where he bought a few inexpensive home-type mouse traps. He sent one of these mouse traps to quality control, along with the engineering drawing. And, sure enough, the mouse trap spring met every qualification of size, strength and quality of the steel used in the manufacture.

So into the Viking went the 10-cent spring from an ordinary mouse trap. It worked on every one of the 12 Vikings that were fired. Now it happens that the first stage of the Vanguard vehicle, essentially an advanced Viking rocket with a new General Electric engine, will also have an electrical access door, and with it the selfsame mouse trap spring.

Thus the first earth satellite vehicle will be initially "sprung" from this earth when a 10-cent mouse trap coil snaps shut the door signaling the start of the rocket.

The above anecdote is but one example of the daily ingenuity and creativity shown by all the members of the Vanguard rocket team, who are pioneering and exploring man's last frontier. The Martin rocket men are dedicated in their quest, and this knowledge should guarantee ultimate success for their part in the IGY's most dramatic single event—the first launching of a man-made moon from the planet earth. Their esprit de corps has been engendered by the knowledge that they are building an air instrument of peace that will help to bind men together in a common cause.

Rocket Fuels at ACS Meeting

Many of the chemicals now serving or expected to serve the rocket field as fuels were discussed last month at the inorganic chemicals division sessions of the American Chemical Society's Annual Meeting in New York. About 15,000 attended the week-long meeting, listening to a total of 1509 reports.

Lithium's future as a high energy fuel and oxidizer for propulsion was discussed as part of the metal's over-all value to industry. Cited were its low weight, high heat of combustion and, as lithium perchlorate, its exceptionally high oxygen bonding potential.

Boron chemicals, the hydrides, the hydrogen peroxide family and hydrazine and its derivatives were the other substances covered at the sessions. Developments in the atmospheric gas industry, including uses for oxygen, nitrogen and argon, were reported. A survey of the fluorine industry completed the papers relating to the missile field.

FMC Expands Chemical Research Activities for Armed Forces

Food Machinery and Chemical Corp., actively engaged in chemical projects for the armed forces since 1946, is currently expanding the research and development aspect of this work.

Noah S. Davis, former ARS president, will continue to head this activity which is performed through a special projects branch of FMC's Central Chemical Research Laboratory located in Buffalo, N. Y.

Plastic Warhead

A new warhead designed and developed by Aerojet-General's Explosive Ordnance Div. for the Army's Nike-Hercules has a body of glass fabric annealed with resin, and is said to give substantial savings of weight in addi-

tion to other still classified advantages not revealed. The Army has issued a $1,846,500 contract to Aeroject for an unspecified number of these warheads.

Arrow Rocket Systems Used On Operation Far Side

Operation Far Side (see ASTRONAUTICS, September, p. 12) will use a cluster of four Arrow II solid propellant rockets for its third stage and a single Arrow II rocket for the fourth stage. But Grand Central Rocket Co., producers of the Arrow, refuses to take credit for the unit. According to Charles E. Barley, GC president, the rockets are in reality motors developed several years ago under Army Ordnance's Loki program at Cal Tech's Jet Propulsion Laboratory. Grand Central's role was to put this motor on a production basis.

Nuclear Plane

Marked slowdowns in development of a nuclear-powered aircraft are being effected, due primarily to a budget cut of two-thirds in the original $600 million request. Air Force officials believed that all of the four principal companies working in the project will continue, but reports circulating in Washington warn that some firms may drop out if their contracts are cut beyond a tolerable level.

Linde Boosts Lox Output

To meet increasing demand, Linde Co., Div. of Union Carbide Corp., is expanding its production facilities at Fontana, Calif. Liquid oxygen and liquid nitrogen capacity will be increased by more than 100 million cu ft per month, equal to more than 140 tons per day.

Lacrosse Production

The Army reported that the first tactical Lacrosse missile has come off the production line at The Martin Co. plant. The missiles are improved versions of the earlier models which were test-fired successfully at White Sands Proving Ground, N. Mex.

Scientists Report On the Ionosphere

Scientists from 15 countries recently met at New York University to discuss ionosphere and radio meteorology developments. The sessions, held as part of the International Geophysical Year, attracted more than 100 experts. A total of 28 papers were delivered.

The Mixed Commission on Radio Meteorology conducted sessions that dealt primarily with turbulence by convection and its relation to lightning and "radar angels." The Mixed Commission on the Ionosphere, meeting simultaneously, heard talks on the various layers in the ionosphere and on speculation about regions beyond.

Among the more stimulating papers presented was that of Sydney Chapman of the Geophysical Institute, College, Alaska, and the High Altitude Observatory at Boulder, Colo., on "The Outer Ionosphere." He speculated that "the terrestrial ionosphere decreases upward in density until it merges with the far extension of the solar atmosphere." Particle density out there would be of the order of 10^3 per cc, and temperature about 200,000 K. This would explain the downward flow of heat by thermal conduction below the F2 layer, Dr. Chapman said. Some theories now consider the exosphere an isothermal layer with temperatures less than 2000 K.

Host to both commissions was NYU's Institute of Mathematical Sciences. Morris Kline, mathematics professor and head of the division of electromagnetic research at the institute, was program committee chairman.

the international scene

News from abroad about rocket and missile activities

BY ANDREW G. HALEY

GERMANY is regaining its former pre-eminence in rocketry. The way back is not through massive groups or large industrial organizations, but through highly competent and dedicated working groups small in number but diverse in skill.

When examined closely the progress in Germany in all fields of astronautics is quite surprising. The country lost its scientists before, during and after the war to other nations all over the world. Gradually some of the greatest returned. Among them were Sänger from France and Georgii from the Argentine, to name just two. The universities and industrial working groups are now adding new generations of future experts, and the renascence goes on.

Here, briefly, is a rundown on some of the leading German institutions concerned with astronautics, their work, plans and personnel. It is, in effect, a capsule of astronautics in Germany today.

Research Institutes

• Institute for Research in the Physics of Jet Propulsion (Forschungsinstitut für Physik der Strahlantriebe e.V., Stuttgart-Flughafen). Directors, E. Sänger and I. Sänger-Bredt. Number of people, 20. Specific items: Mechanics of jet propulsion, especially economic rocket-assisted takeoff units; chemical ramjets and rockets; nuclear jet propulsion systems; physics of chemical and nuclear combustion processes, including the effects of mixture preparation and nonequilibrium phenomena; gas radiation, especially that of combustion gases and plasmas; physics of wall effects, especially heat transfer in boundary layers, as well as gas-kinetic and optical boundary layer phenomena.

• Institute for Applied Gas Dynamics at the German Experimental Institute for Aeronautics (Institut für Angewandte Gasdynamik an der Deutschen Versuchsanstalt für Luftfahrt, Aachen). Director, A. Naumann. Number of people, about 37. Specific items: Transonic flow; supersonic flow; oblique shock diffusers for supersonic ramjet engines.

• Institute for Jet Propulsion Works of the German Research Institute for Aeronautics (Institut für Strahltriebwerke der Deutschen Forschungsanstalt für Luftfahrt, Braunschweig). Director, O. Lutz. Number of people, 14. Specific items: Thermodynamics of chemical reaction; combustion chamber studies; high temperature materials; mixing problems; jet noise.

Development and Manufacturing Organizations

• Bölkow Developments (Bölkow-Entwicklungen KG., Stuttgart-Flughafen). Director, L. Bölkow. Number of people, about 200. Specific items: Development and production of small guided missiles.

• Engineering Bureau (Büro f. techn. Angelegenhéiten Bremen). Directors, A. F. Staats, K. Call, K. Haupt. Number of people, about 20. Specific items: Development of a small sounding rocket for meteorological purposes; development of an aerial delivery rocket and oil-spray rocket; development of an auxiliary take-off unit for soaring planes.

• Dynamite Corporation, formerly Alfred Nobel & Co. (Dynamit Actien Gesellschaft, vorm. Alfred Nobel & Co., Troisdorf b/Köln). Number of people, about 200. Specific items: Development of special fuels for jet propulsion systems.

• Bavarian Motor Works—Study Community for the Construction of Driving Mechanisms (BMW-Studiengesellschaft für Triebwerksbau m.b.H., München). Director, H. Sachse. Specific items: At this time, preliminary design in the propulsion branch.

• Daimler-Benz Co. (Diamler-Benz AG., Aeronautical division, Stuttgart-Untertürkheim). Director, H. Scherenberg. Specific items: At this time, preliminary investigations in the propulsion branch.

• Rocket Manufacturing Co. (Raketenfertigungsgesellschaft mbH, Giessen/Lahn). Number of people, about 100. Specific items: Plans license construction of various types and kinds of rockets.

• Comet Manufacturing Co. ("Comet" Apparatebau GmbH, Bremerhaven). Number of people, about 30. Specific items: Life-saving devices, pyrotechnical articles, fuses.

• Berkholz Company (Berkholz GmbH, Hamburg-Bahrenfeld). Number of people, about 20. Specific items: Life-saving devices, fuses, pyrotechnical apparatus.

Astronautics Publications

• *Astronautica Acta.* Official organ of the International Astronautics Federation. Managing editor, F. Hecht, Vienna; Springer Publishing House, Vienna. (Although not strictly German, this publication serves the German Community).

• *DVL-News* (DVL-Nachrichten). Communications of the German Experimental Institute for Aeronautics. Managing editor, O. Gdanice, Mülheim/Ruhr.

• *The World of Flight* (Flugwelt). Monthly journal for the whole field of aeronautics, official organ of the Federal Association of the German Aviation Industry. World of Flight Publishing House, Wiesbaden.

• *Research Series* (Forschungsreihe). Publication of the former Northwest German Society for World Space Research. Managing editor, H. Kaiser; publisher, German Work Community for Rocket Engineering, Bremen.

• *Aviation Engineering* (Luftfahrttechnik). Organ of the Society of German Engineers, VDI Publishing House, Düsseldorf.

• *Communications from the Institute for Research in the Physics of Jet Propulsion* (Mitteilungen aus dem Forschungsinstitut für Physikder Strahlantriebe). Editors, Eugen Sänger and Irene Sänger-Bredt; Publishing House Aviation Engineering, E. V. Olnhausen, Stuttgart, and Publishing House R. Oldenbourg, München.

• *Physics Sheets* (Physikalische Blätter). Editor, E. Brüche; managing editor, E. Moritz; Physics Publishing House, Mosbach/Baden.

• *Rocket Letter* (Raketenbrief). Communication sheet of the German Work Community for Rocket Engineering. Bremen Publisher Schween, Bremen.

• *Rocket Engineering and Space Travel Research* (Raketentechnik und Raumfahrtforschung). Issued by the German Society for Rocket Engineering and Space Travel, printed by H. Henkel, Stuttgart-Zuffenhausen; organ

of all German-speaking rocket and space travel associations.

• *World Space Travel* (Weltraumfahrt). Editor, H. Gartmann; Umschau-Publisher, Frankfurt.

• *Journal for Aviation Sciences* (Zeitschrift für Flugwissenschaften). Organ of the Scientific Society for Aviation. Vieweg Publisher, Braunschweig.

Astronautics Organizations

• *German Society for Rocket Engineering and Space Travel* (Deutsche Gesellschaft für Raketentechnik ünd Raumfahrt). Stuttgart-Zuffenhausen, Neuensteiner Street 19. (Member of IAF). President, É. Sänger. Officers, F. Gerlach, K. Grupp, W. Georgii, E. Robger, K. Eisele, H. Goeckel, F. L. Neher. Number of members, 1100.

• *German Work Community for Rocket Engineering* (Deutsche Arbeitsgemeinschaft für Raketentechnik e.V., Bremen.). Erlenstreet 6, Bremen. (Member of IAF). Officers, A. F. Staats, F. Schade, H. Langkrär, R. Haber, R. Schoepfer, K. Haupt, Dr. Büchner. Number of members, about 300.

• *German Museum for Rockets and Space Travel* (Deutsches Raketen und Raumfahrtmuseum e.V., Stuttgart). Reinsburger Street 54, Stuttgart. (Member of IAF). Director, A. Fritz. Officers, A. Michely, M. Benndorf. Number of members, about 50.

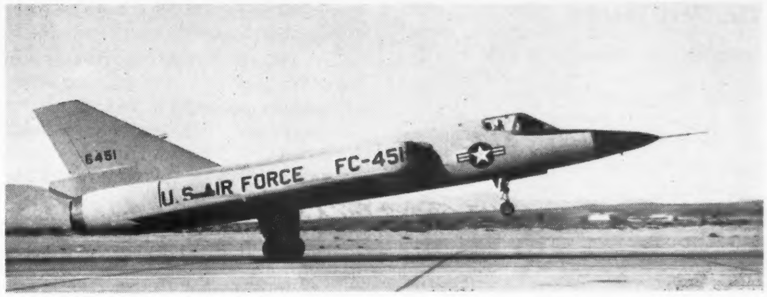
Each paragraph of this outline could easily be converted into a long and interesting story. Take, for example, the significance of the explanation of A. F. Staats with respect to his reply to our queries. He writes that he was delayed in answering because his time was completely taken up by rocket launchings undertaken by the Bremen group at Sahlenburg on the North Sea coast.

These are launchings, not static tests!

Salute to Joseph Kaplan

In this column last month we had a brief look at Athelstan Spilhaus and in the process pointed out that many of the greatest scientists working in astronautics come from the Southern Hemisphere. This month in taking a look at Dr. Kaplan, we incidentally find a flock of astronauts emerging from Hungary, including Kaplan, Teller, von Kármán and a myriad more. Civilization owes to Dr. Kaplan, more than to any other scientist, the initiation of the earth satellite program, which he accomplished in his capacity as chairman of the United States National Committee for the IGY.

Dr. Kaplan has received numerous honors, but none more sincerely given than the ARS 1956 Astronautics Award. He has excelled in biophysics, molecular spectroscopy, spectroscopy related to upper atmosphere, light of the night sky, aurora borealis and composition of the upper atmosphere of the earth. His academic connections have included Johns Hopkins, Princeton and the University of California.



Coming In

First released photograph of Convair's all-weather interceptor F-106A shows ship touching down after test flight at Edwards AFB. Supersonic flight at stratospheric height is standard for the delta-winged aircraft, which is a sister ship to the operational F-102A. Fuselage is pinched at the waist in conformance with the area-rule design.

Flask for Terrier

The Navy's Terrier surface-to-air missile gets its auxiliary power (for actuating internal instruments) from compressed air carried in a $49^1/_2$ lb forged steel flask. A picture of the flask, manufactured by Alco Products, Inc., shows a roughly elliptoid shape with a major diameter of about $1^1/_2$ ft. The weapon itself has a 1 ft diam. Internal test pressures of 7500 psi are specified for the flask.

New Avionics Group

Daystrom, Inc., reorganized many of its subsidiaries into an Avionics Group for the development and manufacture of complete electronic systems for guidance and control of missiles and aircraft. The major shift was the first since the company acquired or formed the subsidiaries beginning more than 10 years ago.

Government favoritism in using contractors who have integrated manufacturing systems was cited as the reason for the changes. Head of the new group is Richard A. Wilson, vice-president, who had formerly been with Magnavox Co. Daystrom sales total about $80 million annually.

Postscript to Rocket Mail

Among the reports to come out of Washington in the Thor-Jupiter IRBM competition was the story about a letter from officers at the Army Ballistic Missile Agency to ABMA Chief Medaris. It was supposedly put into the nose of a Jupiter fired from Cape Canaveral, then recovered after a 1200-mile flight out into the Atlantic and forwarded to Gen. Medaris.

A postscript was added to the episode at a recent press conference held by Defense Secretary Charles E. Wilson. The exchange, as recorded by DOD minutes, was as follows:

Mr. Norman (*Chicago Tribune*): Mr. Wilson, did you have to get any approval from [Postmaster General] Summerfield's office to permit the Army to fire letters by rockets, mail by rockets?

Secy. Wilson: No.

Mr. Norman: Do you know anything about the experiment at all?

Secy. Wilson: No, just what I read in the papers.

Mr. Raymond (*New York Times*): Do you believe that, sir? [Laughter].

Secy. Wilson: It sounds like a funny way for a man to write himself a letter. [Laughter].

Helicopters Armed with Rockets

At the U. S. Army Aviation School, Fort Rucker, Ala., tests are bing continued to further evaluate armament composition and techniques for tactical employment of armed helicopters. Weapons ranging from 0.30 caliber machine guns to 80 mm Oerlikon rockets have been mounted on three types of helicopters, the Bell "Sioux" (H-13 reconnaissance-type), Sikorsky "Chickasaw" (H-19 utility-type) and the Vertol "Shawnee" (H-21 light cargo-type).

The Navy Team

(CONTINUED FROM PAGE 32)

Sonde Branch officially came into being. Using captured V-2's at first, and later a vehicle of their own design, the Viking, this group pioneered the use of rockets in upper atmosphere research.

Then, on Nov. 24, 1954, Milton Rosen—this time in his capacity as chairman of the AMERICAN ROCKET SOCIETY Space Flight Committee—made another proposal. This one was directed to the National Science Foundation and suggested that this body sponsor a study of the "utility of an unmanned earth satellite vehicle."

It was only fitting (and expedient) that when the government actually decided to launch such a project that NRL be called in to direct the program. Martin, maker of the Viking, was made prime contractor for the three-stage launching vehicle. The men at NRL—most of them from the Rocket Sonde group and many of them carryovers from the Viking program—were given the job of carrying out the over-all technical program for Project Vanguard.

The Top Men

The man who was assigned the responsibility for the Naval Research Laboratory's participation in the scientific aspects of this program is Homer E. Newell Jr.

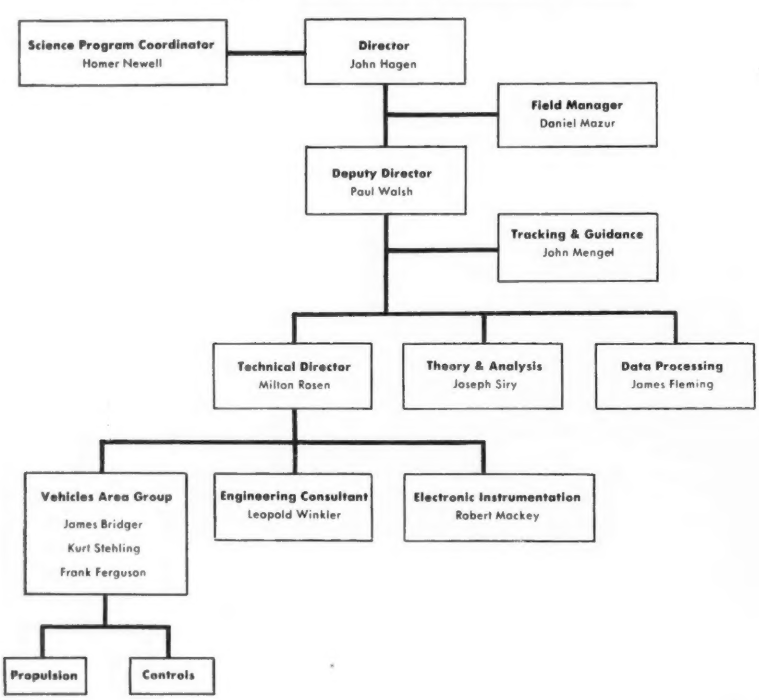
Designated science program coordinator for Project Vanguard, Dr. Newell actually performs a number of jobs on the project. He provides over-all direction of the Vanguard science program. This includes the building and instrumentation of the satellites. And as a member of the Technical Panel on the Earth Satellite Program, he acts as a coordinator for NRL on the project.

In addition, Dr. Newell is currently engaged in numerous other activities which are not directly related to the satellite project. He is, for example, a member of the Upper Atmosphere Rocket Research Panel, is now serving as executive vice-chairman of the United States National Committee-IGY Technical Panel on Rocketry, and is acting as chairman of the panel's Special Committee (Working Group).

Dr. Newell joined NRL in 1944. In 1947, he became head of the Rocket Sonde Branch and, in this capacity, directed NRL's high altitude rocket research program including the development and use of the Viking, forerunner of the Vanguard. In 1955, Dr. Newell was named acting superintendent of the Atmosphere and Astrophysics Div.

He holds a doctor's degree in mathematics from the University of Wisconsin. He taught there and at the University of Maryland before joining NRL.

NRL's Project Vanguard Organization Chart



Actual project director of this top priority U. S. research program is Canadian-born John P. Hagen. It is Dr. Hagen's job to direct and coordinate the Vanguard program within NRL.

In his official capacities, he heads NRL's table of organization for Project Vanguard, is a Defense Department Counterpart Member of the USNC-IGY Technical Panel on the Earth Satellite Program, and serves as a consultant to the panel. Unofficially, Dr. Hagen, a friendly and patient person, has also done an effective public relations job in promoting general interest in this highly scientific venture through his appearances before press and public.

Educated in the U. S., he obtained his Ph.D. in astronomy from Georgetown University. He served as an assistant in physics at Wesleyan University for six years and then joined NRL in 1935. In 1954, he was appointed first superintendent of the laboratory's newly formed Atmosphere and Astrophysics Div., the job he will return to at the conclusion of Project Vanguard.

Administrative Scientists

In September 1956, he appointed J. Paul Walsh his deputy director. Walsh has been at the laboratory since 1943 and has served as a consultant to the earth satellite program since October 1955.

A top-flight mechanical engineer, Walsh has done important research in the areas of shock and vibration and in underwater acoustics. But his ability as an administrator was perhaps more important in bringing him into Project Vanguard as deputy to Hagen. In any event, Walsh, in his present position on the project, carries a major share of the Vanguard administrative responsibility.

Another excellent administrator on the Vanguard staff is Daniel G. Mazur, manager of Vanguard Operations Group at Patrick AFB. Appointed to his present post only last August, Mazur supervises the Navy's part of the earth satellite operations at Patrick.

Mazur is an electronics engineer who has specialized in the design and operation of rocket telemetering. He joined NRL in 1946 and has been closely associated with the Viking and other high altitude rocket projects. Before going to Patrick, Mazur served as head of the Electronic Instrumentation Branch of Project Vanguard. He is recognized as one of the country's leading authorities on instrumentation and telemetering.

John T. Mengel also joined NRL in 1946. A physicist, he served ini-

tially as a member of the Rocket Sonde Research Section. In this group, he was responsible for the design and fabrication of the first research nose shells to replace the warheads of V-2's used in this country for high altitude research.

In 1947, Mengel became head of the Electronic Instrumentation Section with the responsibility for telemetering and emergency cut-off. He was made coordinator of guidance in the Rocket Development Branch in 1954. Since 1955, Mengel has been head of the Tracking and Guidance Branch of Project Vanguard with the responsibility of acquiring and tracking the earth satellite by radio methods.

Two old NRL hands (in point of service, that is) with somewhat related jobs on the project are Joseph Siry and James Fleming. Siry heads theory and analysis and Fleming is in charge of data processing.

It will be the job of Siry's section to compute orbits of the satellite, and study ballistic properties of the vehicle and performance. Fleming is responsible for all reduction of flight data and has charge of a radar section and of an orbit computing facilities section. Siry, who has an orbit determination group, will determine what the satellite and vehicle should do; Fleming will determine what they actually did.

Perennial Rocketeer

No major rocket research program would be complete, of course, without Milton Rosen. And on Project Vanguard, he fills the very important position of technical director. As such, he is responsible for all technical aspects of the satellite vehicle and the primary tracking system. This takes in such things as instrumentation, structure and launching of the vehicle. He is also responsible for the satellite structure.

Rosen's many years on the Viking program have uniquely qualified him for his present post. The Viking, developed under his direction, provided much experience and many basic lessons that have found immediate and direct use in the Vanguard project. An electrical engineer, he joined NRL in 1940, and he was one of the original group at the laboratory which proposed and help set up the Rocket Sonde Branch in 1945.

A long-time member and present director of the American Rocket Society, Rosen received the Society's James H. Wyld Memorial Award in 1954 for his work on the application of rocket power.

Assisting Rosen in the execution of his responsibilities are three important sections which are responsible for different technical areas. These are: Vehicles Area Group, Engineering Consultant and Electronic Instrumentation.

The Triumvirate

The Vehicles Area Group, in turn, is actually composed of three indistinct groups—Vehicles, Propulsion, and Guidance & Controls—bound together under the heading of their prime responsibility, the earth satellite launching vehicle.

James M. Bridger is the head of the Vehicles Branch. He is responsible for establishing requirements, monitoring development and testing, performance analysis, and evaluation of the three-stage rocket launching vehicle. He is senior NRL representative at The Martin Co. which holds the prime contract for the vehicle.

Distantly related to famed Indian scout Jim Bridger, he joined the Navy in World War II and was responsible for the development of radio, radar and guided missile electronic countermeasures equipment. After his release, Bridger, a physicist, joined NRL in 1946. He went to work with the a-borning Rocket Sonde Section and was responsible for the development of the Viking control system.

Kurt R. Stehling heads the Vanguard propulsion group. His job is the supervision of powerplant development and, as such, means close liaison with The Martin Co. both in Baltimore and at Patrick AFB. One part of his group, in fact, is stationed at Patrick. The work covers the arrangement, review and approval of specifications for the powerplant and auxiliary components, as well as the monitoring of Martin's propulsion activities.

A physicist and rocket research engineer, Stehling joined NRL in 1955. Like Rosen, he is also a director of the American Rocket Society and was active with Rosen on the ARS Space Flight Committee which submitted a satellite proposal to the National Science Foundation in 1954.

Frank H. Ferguson is the third member of the Vehicles Area Group triumvirate. Ferguson is in charge of controls and guidance. As such, he is responsible for the successful operation of the gyroscopic and electronic devices in the vehicles which will bring it into the desired flight path.

Before joining the Vanguard staff, Ferguson worked on servomechanisms and computer design at NRL.

Satellite Consultant

More concerned with the satellite than with the launching vehicle is Leopold Winkler. In charge of building the satellite spheres, Winkler is engineering consultant to Rosen on structures.

Also a Viking graduate, Winkler carried out some important and rather basic work in high altitude rocket photography and is largely responsible for those first striking photographs showing the earth's curvature as seen from a high-flying sounding rocket.

Robert Mackey, head of electronic instrumentation, rounds out this thumbnail profile of NRL's Vanguard personnel.

Mackey has charge of range safety, tracking and various telemetering areas. This includes putting the transmitters and telemetering equipment in the vehicle and setting up ground stations to pick up the signals from the vehicle. Like most of the others, Mackey is also a former Viking man.

From NRL's first V-2 to Vanguard has been a giant step; but as one Navy man points out, it's still a long climb to the stars.

Javelins Join Up

British Gloster Javelin all-weather night fighters are now in squadron service with the Royal Air Force. The plane is powered by two Armstrong-Siddeley Sapphire turbojets.

IGY notes

Delegates from about 40 countries to the International Union of Geodesy and Geophysics at Toronto last month were specially interested in the earth satellite experiments, according to reports. The baby moons set the tone for the parley, both in papers and in exhibits. But Toronto wasn't the only place where satellites made news.

Russia revealed that its satellites will be of two types: One, a hollow aluminum sphere 25 in. in diam and 22 lb in weight, will be crammed with instruments; the other will carry no instruments and will be an excellent light reflector, presumably intended for geodesy measurements.

Cuba has allowed a Minitrack station to be built 30 miles from Havana to follow the U. S. satellite. Cost of construction and operation will be borne by the U. S.

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Project Sunflare, involving Nike-Deacon and Nike-Asp rocket firings from San Nicolas Island, Calif., to study radio propogation interference, is being conducted by Cooper Development Corp. under the direction of the Naval Research Laboratory.

•

A giant, unmanned balloon, equipped with a 12-in. telescope camera that is aimed by a light-sensing unit, is being used by the Navy to take still pictures of the sun. The photos should be three times sharper than any taken previously. During three planned flights, some 8000 pictures will be taken by the camera after the balloon has reached 80,000 ft.

•

Radio physicists are establishing mobile stations in South America to study forward scattering of high-powered transmissions that bounce off the lower ionosphere. The scientists, from the National Bureau of Standards at Boulder, Colo., are setting up seven stations in five countries.

Russia Listens **Reception antenna of the Russian Communications Ministry's radio telescope, located in the Moscow region, is shown in this photograph. The instrument is tuned for solar radiation as part of the Soviet IGY contribution.**

"Rivers of electricity" girdling the earth have been under study as part of the over-all IGY program. Theory is that streams, such as the Equatorial Electrojet, are generated by tidal movements of the earth's atmosphere.

•

Only four countries have refused to contribute to IGY activities, according to dispatches from headquarters at Uccle, Belgium. They are Syria, Iraq, Turkey and Lebanon.

Re-entry Problems

Avco Mfg. Co. reported a "major theoretical breakthrough" in the nose cone heating problem for an ICBM, made possible by shock tube experiments. Prototypes of Titan ICBM nose cones, embodying the development, have been built in Avco's Lawrence, Mass., laboratory. Avco has a $111-million prime contract for such development.

Cornell Aeronautical Laboratory investigators have suggested that small dust particles in the air may markedly affect missile behavior on re-entry. Using hypersonic shock tunnels, they hurled dust onto a blunt-nosed model at high speeds. Studies showed that, on being reflected, the particles create in their wake a pointed cone in the air ahead of the model. This cone, though it collapses almost immediately, intersects and disrupts the normal shock wave around the model's nose. Heat transfer as well as flight path of the missile could be influenced by such phenomena.

ICAO Outlines Jet Age Needs

A detailed blueprint of the needs of aviation's coming jet age is contained in a report made to the International Civil Aviation Organization's Air Navigation Commission by ICAO's Jet Operations Requirements Panel. The group is composed of experts from government aviation agencies, manufacturers of turbojet and turbopropeller aircraft, and airline and airline pilot associations.

The report defines new air navigation aids and services, changes in aerodrome construction and air traffic control practices, improvements in meteorological forecasting and reporting and in aeronautical communications, which will be required by the introduction of the fast, high-flying turbine aircraft due to appear on the world's air routes during the next few years.

Three Engines

(CONTINUED FROM PAGE 46)

tinuous feed type, rest. Under usual conditions of chemical reaction, the electrical transfer takes place directly from reductant to oxidant, the major effect being to change the chemical energy into heat.

However, it is possible to force electron transfer through an external circuit. This is important when you realize that, in the relatively few laboratory cases where such systems have been worked out, the energy change involved can be carried out at efficiencies of better than 80 per cent, compared to the 35 per cent figure associated with heat engines now in use.

One requirement of such a system is to force the electron transfer through an external circuit, which demands that the reductant (electron donor) be physically separated from the oxidant (electron acceptor). If the reductant and oxidant now are connected with copper wire, an electrical conductor, the electrons can flow from the reductant to the oxidant. If an appropriate aqueous solution of ions is placed between the separate electrodes, an internal ionic flow takes place. Under these conditions, the external electrical flow will continue as long as the supply of oxidant and reductant is maintained. An example of an elementary electrochemical cell is shown on page 45.

Principle is Old

The concept of an oxidant physically separated from a reductant by means of an ionically conductive but electrically insulated surface is well illustrated by every known battery system. The dry cell uses manganese dioxide (oxidant) separated from zinc (reductant) by a solution essentially of ammonium chloride.

Consider as an example an electrochemical cell based on the principle that sodium dissolved in liquid mercury can be pumped as a reductant while oxygen gas can be used as the oxidant. Mercury is not consumed in the reaction but just acts to simplify the feeding of the sodium. The fundamental cell reaction would be: $4Na + O_2 + 2H_2O = 4NaOH$.

From this reaction, it follows that, at 100 per cent electrochemical conversion, 92 grams of sodium react with 32 grams of oxygen and 36 grams of water to produce 160 grams of sodium hydroxide, and thereby generate a total of 4 Faradays of electricity, or 386,000 amp-sec. This is equal to 107 amp-hr. Thus, one pound of fuel will generate 340 amp-hr.

Below are summarized some of the more obvious electrochemical systems:

Reactants	Products	Theoretical performance lb/hp-hr
$H_2 + \frac{1}{2} O_2$	H_2O	0.45
$C + O_2$	CO_2	0.66
$\frac{1}{2} H_2 + \frac{1}{2} Cl_2$	HCl	1.60
90% H_2O_2	$H_2O + \frac{1}{2} O_2$	2.0

In view of the fact that the little experimental work that has been done in the laboratory to date has yielded high conversion efficiencies, one would be led to believe that an electrochemical cell may have a promising future.

Many engineering problems remain with the development of electrochemical cells. Pumps, plates and other engineering problems must be worked on to convert such a cell into a useful form. It also has the potential of operating in areas where more conventional powerplants cannot function. It is independent of the atmosphere and has the advantage of directly generating electrical power. In addition, the fuels are substances that are plentiful and often inexpensive.

Mechanochemical Engine

The study of the direct mechanochemical process, as exemplified by a human muscle, is tempting even from a practical point of view, for the efficiency of such living "engines" compares favorably with the best heat engines. The muscles of the athlete, for example, convert almost 45 per cent of the energy stored in foodstuffs into useful work, while a modern steam turbine has no better than about 40 per cent efficiency. In recent years, a good deal of effort has been expended in trying to understand in just what manner the human muscle functions. Considerable success has been achieved in this direction, and Dr. Albert Szent-Gyorgi has received a Nobel Prize for his work in this area.

Many natural and synthetic gels have the property of contractility. The word gel may suggest only a soft jelly, but it also denotes some of the strongest living structures, including muscles, tendons, hair and skin. The fundamental structure of any gel is a substantial micro-network of large molecules or very small crystals joined together at numerous cross-linking points. Within this mesh is entrapped a liquid that permeates the material.

The network endows a gel with elastic and tensile strength. In certain gels which are of particular interest to muscle chemistry, the network is made up of thread-like molecules, sometimes consisting of thousands of atoms linked together. Such molecules are very flexible and tend to coil up under the impact of thermal movement of neighboring molecules in the gel. When held in a gel network, they are as elastic as rubber, which has a similar structure.

Imagine now that the molecule chains of the network carry chemical groups able to combine with a substance dissolved in the liquid which permeates its meshes. If the reaction causes the chain to uncoil, the network will expand and the gel as a whole will swell. On the other hand, if the molecules are already extended by some external force, certain chemical reactions may cause the chain to coil up and the gel to contract. When a weight is attached to the gel, this contraction will lift the weight, thus performing work.

It is possible to reverse the chemical action so that the gel undergoes a cycle of alternate contractions and expansions. In such a cycle, the chemical compound that reacts with the gel must enter it with the first half cycle and leave it during the second half. The compound must have a higher chemical potential when it enters a gel engine than when it leaves.

Thus, the mechanochemical engine works on a chemical potential difference, in much the same way that a turbine operates on pressure difference. Its efficiency depends on its ability to convert a high chemical potential difference into contracting forces in a gel network.

On pages 45 and 46 are shown some of the experiments conducted in this area by A. Katchalsky and S. Lifson of the Weizmann Institute in Israel. The action of the human muscle was simulated by alternately dipping synthetic gels in acids and bases. When hydrochloric acid was added to the solution, the gel contracted; when sodium hydroxide was added, the gel expanded.

Katchalsky and Lifson also constructed a small mechanochemical engine based on this principle. The engine, shown on page 46, was made up of five strips of synthetic gel, connected to a heavy weight by means of pulleys, and immersed in a solution. When the acidity of the solution was changed, the strips expanded and contracted, lowering and raising the weight, and thus forming the simplest kind of engine.

The future will see many new engines unfamiliar to us today. Necessity, imagination, research and engineering will bring them into being.

Some may even find their way into tomorrow's space vehicles.

in print

Earth Satellites and the Race for Space Superiority, by G. Harry Stine, Ace Books Div. of A. A. Wyn, Inc., New York, 191 pp., illustrated. 35 cents.

This seems to be open season for books on earth satellites. Apparently every science writer in the business has approached his publishing house about doing a book on satellites and gotten the green light, and it has reached the point where a publisher without a book on the subject must feel like a social outcast.

Unfortunately, the definitive popular work in the field still remains to be written. All those that have already been published have had something to contribute, but most, like this latest effort, use the subject of earth satellites primarily as a springboard for the author's prophecies about the shape of things to come. None has taken a good long look at earth satellites, what they are, how they work and what can be accomplished through their use.

Roaming Romantic

This newest attempt by G. Harry Stine, a rocket engineer at White Sands Proving Ground, is no exception, although in this instance at least the title indicates Stine started out with something a little broader in mind. In any event, satellites get short shrift here, most of the material on this subject being confined to the first few chapters. Beginning with Chapter 6, Stine roams freely through the future, offering his own timetable of coming events in space flight.

Last month in these columns, Col. John P. Stapp wrote of the Romantic movement in physics, a movement requiring "a brave disregard of details in order to consider the awesome whole." A similar movement seems to be taking place in the field of science writing, and especially in writing about rocketry and space flight, which contrasts the "It's-easy-let's-get-on-with-the-job" writer and the "Wait-a-while-it's-not-as-easy-as-you-think" man.

There can be little doubt that Stine is a charter member of this Romantic school of science writing. In fact, it's unnecessary to read beyond page 10 to realize this, for here we find the author stating unequivocally that "within 10 years of its first entry into outer space, the Vanguard program will no longer need to exist, for men will be there to see for themselves, riding along in larger and more powerful rockets to enter outer space and stay there."

From these beginnings, Stine projects an entire future history of space flight. His timetable proceeds from Vanguard and the ICBM to a long-range manned rocket research vehicle by 1961–1962, a 3000-mile rocket transport and passenger ship by mid-1965, an interim manned orbital ship by 1967, a manned orbital reconnaissance vehicle in 1968, and manned ferry rockets, along with a full-scale manned orbital space station, by 1970. It's just as simple as that, for Stine makes it perfectly clear that, as far as he's concerned at least, not only *can* these projects be carried out, but also that they *will* be accomplished by these dates.

Many of these proposals will be familiar to ARS members from national meetings, since the concept of Stine's own "Griffon" research vehicle and Darrell C. Romick's "Meteor" ferry rocket and space station were originally presented as papers at these meetings.

All of these proposals are interesting and Stine's temerity in predicting exactly when each will come to pass even more so. However, it seems curious that, in a book in which considerable thought has been given to the technical side of getting such vehicles out into space, so little attention is given to the human factor.

Every one of the ships the author mentions is a manned vehicle, and yet the physiological and psychological problems involved in putting men into such ships is glossed over with a few words about weightlessness. Certainly any attempt to forecast manned space flight requires some serious consideration as to whether or not man will be able to make such flights, especially if, as the author assumes, we already have the technical know-how to get the vehicles up there.

Make Things Come Alive

Despite these faults, the book is a stimulating one. Stine, perhaps better known as an author of science fiction under the pseudonym of "Lee Correy," has the professional writer's ability to make things come alive. Certainly his descriptions of a Vanguard firing and conception of the take-off of an Aeolus passenger rocket plane or the firing of a Meteor ferry rocket are outstanding in a field where such writing is often stodgy.

Everyone in the rocket and guided missile field frequently is called upon to explain "what this space flight business is all about." Harry Stine's book, certainly one of the least expensive ever published on the subject, and containing some reasonably good illustrations, would make an excellent gift to keep handy on such occasions, even though the professional engineer might find it of little interest.

—I.H.

Coming Attractions, edited by Martin Greenberg, Gnome Press, New York, 1957, 254 pp., illustrated. $3.50.

This is an odd but interesting book that almost defies classification. Published by a well-known science-fiction house, it is described as "non-fictional science fiction" on the jacket, and this description will do as well as any other for a potpourri made up of 11 articles ranging over a wide field of provocative subjects.

Most of the articles are taken from *Astounding Magazine*, which, among science-fiction publications, has long been outstanding for its presentation of speculative science-fact articles of this type. Despite the fact that several of the articles are more than 15 years old, it is rather surprising to find how well most of these have stood the test of time.

In the course of debunking many of the pet theories and ideas of the run-of-the-mill science-fiction writer, the authors provide some food for thought for engineers and scientists currently wrestling with the problem of space flight.

Perhaps the most interesting article from this standpoint is Jack Hatcher's contribution, entitled "Fuel for the Future." The fuel Mr. Hatcher is talking about is *not* the fuel that will power tomorrow's space vehicles, but the food, water and oxygen that the space man of tomorrow will require either during his journey or in future colonies on the moon or on other planets.

In a carefully thought out, well researched article, the author demolishes the science-fiction writer's dream of the space man "gulping his food in three small tablets and promptly feeling fit and fresh again," and goes to some pains to point out exactly how much actual poundage will be required in the way of foodstuffs. His conclusion—about 6 lb of assorted compounds per human per day—indicates that the job of providing the first space man with sufficient food to keep him alive over a fairly long journey is still far from solved.

Willy Ley, a past master at this

kind of writing, in an article on "Space War," and Malcolm Jameson, in "Space War Tactics," also debunk some favorite science-fiction ideas. Mr. Ley points out that the fantastic offensive and defensive weapons envisaged for tomorrow's space ships by some writers are either impossible or unnecessary, and notes that a common, ordinary 75-mm gun will probably prove most effective in putting a space ship out of business.

In "A Letter to the Martians," Mr. Ley copes with something that has engrossed many leading scientists, among them Claude Sharron of Bell Labs—the problem of explaining to intelligent inhabitants of other planets (providing that we find them, of course) who we are and where we came from. In "How to Learn Martian," Charles F. Hockett takes up the problem of learning a language completely foreign to us.

Frederik Pohl's "How to Count on Your Fingers" is a stimulating and witty introduction to the binary system of numbering and computers, while R. S. Richardson's contribution is an article on space navigation which, while it may contain little of interest to specialists in this field, provides an analysis of basic problems.

While the other articles in the book are not concerned with space flight, most of them are enjoyable, with top honors going to L. Sprague De Camp for his admirably written, humorous "Language for Time Travelers," and to the prolific Mr. Ley for his "Geography for Time Travelers."

The book is well-illustrated with line drawings and can be wholeheartedly recommended to anyone looking for something a little offbeat to read on a cold winter night.

—I.H.

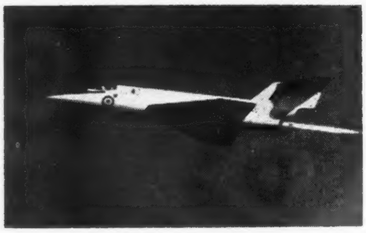
Oxygen from Plants But . . .

Deadly, insidious carbon monoxide is also secreted from some of the green plants, like algae, that have been proposed as a source of food and oxygen during space flight. Dr. Syrrel S. Wilks of the Air Force School of Aviation Medicine, Randolph AFB, made the discovery.

Honors for Martin

The Martin Co. is slated to receive the coveted John Price Wetherrill Medal of The Franklin Institute in recognition of the intensive research, development and manufacture of bonded structures, at the institute's annual Medal Day ceremonies, Oct. 16. This is the first time in 25 years that a company rather than an individual was cited.

British Rocket-Jet Plane



Britain's Saunders-Roe S-R 53 fighter takes off with shock beads clearly visible in its liquid rocket exhaust. Sustained flight is by turbojet.

Details of the rocket engine of the Saunders-Roe S-R 53 mixed powerplant interceptor have been revealed by its manufacturer, the de Havilland Engine Co., in conjunction with the Farnborough exhibition.

Designated the Spectre, the kerosene-hydrogen peroxide engine is an integral unit incorporating all its pumps, valves and controls in a compact, light assembly. The kerosene fuel is the same as that used in the Armstrong-Siddeley Viper turbojet, the second powerplant of the plane. Spectre engine is capable of operating at full thrust for several minutes and can tolerate repeated starting and shutdown during any given flight.

A single combustion chamber, regeneratively cooled by the 83–87 per cent pure hydrogen peroxide, permits continuous variable thrust output. A separate peroxide supply drives the turbine pumps for the propellant and oxidizer.

Navy Stretchout

Missile production was unaffected recently by Navy stretchout orders. Aircraft procurement rate was extended, however, as a result of the economy wave and technological advances.

Ramjet Control Systems

(CONTINUED FROM PAGE 39)

trated on page 38. This type of facility has been extensively used for investigations of ramjet internal flow with engines as large as 48 in. in diam. Air at high pressure and temperature is expanded through a supersonic nozzle and the jet discharges into a low-pressure chamber. The ramjet is mounted with its inlet submerged within the jet. If the jet is sufficiently large compared to the engine inlet, good simulation for both subcritical and supercritical operation is provided.

In general, supersonic nozzles are of a fixed configuration, and thus there are no highly stressed walls to cause concern at high air temperatures. This permits use of higher air temperatures than have heretofore been feasible in supersonic wind tunnels. No difficulties have been experienced with stagnation temperatures in excess of 900 F, and it is quite certain that rocket nozzle cooling techniques can be applied to permit much higher temperatures. The use of fixed configuration nozzles requires that nozzles be changed for tests at different Mach numbers.

Once a suitable environment has been arranged for the test engine, we can concern ourselves with test methods and the special equipment needed. As noted, we are primarily interested in the behavior of engine pressures in an unsteady environment. Thus we must introduce disturbances whose results may be readily measured and analyzed. The information required can be obtained from the response of the engine pressures to step, ramp, sinusoidal or arbitrary disturbances. Each of these methods has advantages and disadvantages. However, the equipment required to create the disturbances and the instruments needed to measure the effect are generally the same.

Test Methods

The simplest way to disturb engine operation is by changes in fuel flow. This is readily done by using a specially designed fast response fuel control valve, such as that shown schematically on page 38. The device has a throttle valve actuated by a hydraulic servomotor and a regulator valve arranged in such a way as to keep a constant differential pressure across the throttle. The regulator valve and throttle-servomotor are carefully designed to provide fast response. The hydraulic servomotor is controlled by an electric torquemotor, so that electrical signals can be used to prescribe the fuel flow passing through the valve. A feedback system assures good correspondence between input voltage and throttle valve position. Because the regulator valve maintains a constant differential across the throttle even at high frequencies, fuel flow is proportional to input voltage.

Rapid Mach Number 1 Changes

Although the Mach number in a supersonic wind tunnel can be changed by bending the flexible throat walls, the time required to do so is quite long. One technique for creating Mach number disturbances more rapidly uses Prandtl-Meyer expansion about a plate mounted parallel to the engine axis to create a field of flow having a Mach number higher than the tunnel Mach number, but the field exists only in the vicinity of the engine inlet.

If the engine is now rotated on its angle-of-attack apparatus, the Mach number of the flow directly in front of the inlet will change with the angle of rotation. The pressure of the flow field also changes with the angle of rotation so that the change of Mach number is accompanied by a change of simulated altitude. It has been found possible in one instance to change the Mach number from 1.77 to 1.67 in 0.7 sec. At the present time, no Mach number disturbances have been used for free-jet facilities, although several intriguing devices are being considered.

The same apparatus used to rotate the engine for Mach number disturbances can be used to create angle-of-attack disturbances, as shown on page 38. This can also be done in a free-jet, of course, but in one installation it was considered more feasible to rotate the nozzle while the engine stayed fixed. Rates of change of angle of attack up to 11 deg per sec have been used in past investigations.

Internal Pressures

The inlet pressure of a free-jet facility is regulated by valves which can be used to create disturbances in simulated altitude. Rates of change of 100 psf per sec have been used in the past. Greater rates can be obtained if the valves and piping are designed with this service in mind.

Measurement of pressure within the engine is accomplished with transducers, generally of the variable-reluctance type, which convert pressure signals to electrical signals. The response characteristics of the transducer in general are more than adequate if the transducer is mounted right at the pressure hole in the engine. Frequently, however, it is necessary to place the transducer some distance away and connect it to the pressure hole with a length of tubing. The addition of a few inches of tubing considerably alters the response and must therefore be considered.

When fuel flow disturbances are used in a dynamics investigation, measurement of the instantaneous fuel flow must be made. Fuel pressure at the fuel nozzles can be used as a measure of the disturbance amplitude. However, the fuel pressure varies as the square of the fuel flow, so a correction must be used to convert pressure amplitudes to flow amplitudes.

The fast response fuel valve can

provide the instantaneous flow measurement in some cases. As noted, a good correspondence exists between flow and input voltage. If fuel flow through the valve is plotted against input voltage, we find a linear relationship exists, and the data fall within $2^1/_2$ per cent of a mean line. If the fuel pipe between engine and valve is short, the valve position signal serves adequately as a measure of the fuel flow up to frequencies of about 50 cycles per sec. However, if the fuel pipe is about 15 ft long, appreciable errors can occur even at lower frequencies. Hence the valve should be placed as close to the engine as possible.

The transducers provide an electrical signal that is proportional to the pressure, and this signal is converted into a permanent record by means of recording oscillographs. Both photographic and direct inking types have been used. Each is adequate for the range of frequencies encountered in ramjet dynamics. Generally, it has been found convenient to use the photographic oscillograph for data recording and the direct-inking type for monitoring during the test run, thus giving immediate indication of the progress of the test.

Test Results

Now that the equipment and methods of dynamic testing have been described, let's take a look at the end results of a typical investigation.

An oscillograph record of a test with a sinusoidal fuel flow disturbance of 0.2 cycles per sec frequency is shown on page 39. Most of the signals shown have considerable noise or high frequency variations superimposed upon the basic test oscillation. When these raw data are used, this noise is ignored and only the frequency component of the input considered. The top line is the sinusoidal variation of fuel flow imposed by the fast response fuel valve. Pressure signals below are located at stations spaced lengthwise through the diffuser duct. They are in order, starting at the diffuser outlet (P_{11}) and progressing upstream.

It is interesting to note that pressures at the forward end tend to be flat on the low pressure half of the cycle. This clipping results when the diffuser normal shock wave passes downstream of the pressure hole. When this happens, the flow is supersonic across the hole and the pressure no longer varies, even though the pressure downstream of the shock is still changing.

These data can be reduced by scaling off the amplitudes of input and output signals and scaling off the horizontal, or time-wise, displacement of the oscillations. This is done for a wide range of frequencies, and the results can be plotted as shown on page 39. Here, the ratio of output amplitude to input amplitude, normalized to 1.0 at low frequencies, is plotted against the disturbance frequency. The lower curve is the time-wise displacement between output and input measured in degrees and more commonly referred to as "phase lag." This type of dynamic response can be represented by an equation which controls-people call a lead-lag transfer function with dead time.

Dead time, which is a time delay during which the output is unaffected by the disturbance, has a value of 15 millisec. The time constant, which represents the time subsequently required for the output pressure to attain 63 per cent of its final value, has a value of 57 millisec. These times can be considered as typical, in order of magnitude, for a full-scale ramjet engine.

A useful description of the dynamic response of a ramjet would involve similar curves for several locations of the pressure measuring hole, other flight Mach numbers, other altitudes and perhaps for representative angles of attack or angles of yaw. The investigation would likely involve disturbances of Mach number, angle of attack and pressure disturbances. Thus what we see here is but a small part of the data to be analyzed in a controls development program.

Data Value

These, then, are the techniques, facilities and instrumentation required to obtain ramjet dynamic characteristics. Once obtained, the dynamic description of the engine serves to expedite the development of the desired control system. These facilities and methods have been used at Lewis Flight Propulsion Laboratory to contribute to the development of engine controls for several of the nation's supersonic aircraft. In these instances, the resulting control system was subjected to proof testing with the same facilities and equipment used in the dynamics testing. Such proof testing demonstrates freedom from divergent oscillations or instability of the final control version.

The probability of a successful first flight is immeasurably increased as a result.

from the patent office

BY GEORGE F. McLAUGHLIN

Liquid Propellant System For Producing High Energy

In previous methods of supplying liquid propellants in rocket motors, a turbopump or similar device is necessary to provide pressure for forcing liquid through an injector into the combustion chamber. Use of a turbopump system requires apparatus for driving the turbopump, adding weight to the rocket.

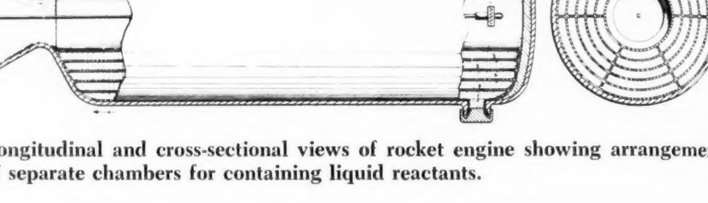
Another method for supplying liquid propellant has been to provide a gas pressurizing system. The gases must be stored in high pressure tanks which require relatively thick walls and the increase in weight cuts down the amount of fuel the rocket can carry.

A system for supplying the propellant without requiring turbopumps or gas tanks uses solid propellants within the combustion chamber. In this case, the propellant is cast within the chamber at the time it is being constructed, and considerable care must be exercised in transporting the rocket. Solid propellant rockets are dangerous during handling because the constituents of the propellant must be initially mixed so as to be in contact with each other and are easily combustible by friction and impact.

The high energy gas producer which is the subject of the patent described here has a cylindrical casing enclosing an expendable cellular-like structure lining the inside. The lining has longitudinal walls extending the entire length of the casing. Partitions extend longitudinally and radially outwardly, forming longitudinal segments, each having transverse walls dividing each segment into small chambers. Each chamber is separated from (and has no communication with) its adjacent longitudinally positioned chamber. Each chamber is separated from the adjacent chambers which are positioned radially outwardly, but are in communication therewith through an orifice. Each adjacent radially inwardly chamber contains the same reactant. Means are provided for rupturing the innermost longitudinal chambers to enable the different reactants to chemically unite to produce the gaseous products for generating thrust. Each longitudinal row of chambers ruptures to produce a sustained length of combustion rather than a single explosion.

Advantages claimed for the system are:

1. Rocket weight is kept to a minimum, permitting additional fuel to be carried.



Longitudinal and cross-sectional views of rocket engine showing arrangement of separate chambers for containing liquid reactants.

2. The design has the features of a solid propellant rocket without the dangers inherent in the latter.

3. No pressurization and fuel system is required for supplying liquid propellants to the combustion chamber.

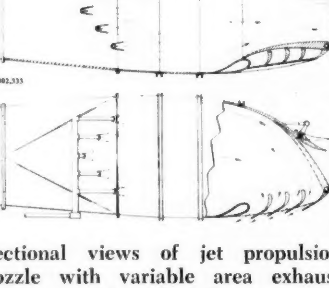
4. The liquid system requires no moving parts.

High energy gas producer (Patent No. 2,802,332). Anthony Joseph Orsino, Schenectady, N. Y., assignor to General Electric Co.

Direction Changing Propulsive Nozzle

The present invention provides reactive jet producing nozzle means wherein the cross-sectional area of the nozzle may be increased for afterburning or reheat operations, and the direction of the discharging propulsive jet may be changed or reversed to obtain a braking action. The shape of the nozzle and tail pipe regions are such that the engines may be installed in side-by-side relation.

The aft portion of the nozzle is rectangular, its major dimension extending spanwise. It has a single gate adapted to be moved between a normal position where it restricts the nozzle for normal flight, and an open position where the nozzle area is appreciably increased for augmented thrust during afterburning. The rectangular nozzle also makes it practical to employ a single movable closure or gate at each nozzle for varying the cross-sectional area of the outlet.



Sectional views of jet propulsion nozzle with variable area exhaust (above), and with deflecting vanes set for thrust reversal.

Turning vanes for directing the gas stream forwardly or in the oblique direction have flaps that extend between the adjacent vanes.

The direction changing nozzle may be used on jet powerplants for aircraft designed to rise vertically during take-off, assume a normal flight course, and descend vertically to land.

The main direction changing valve or gate is near the approach to the nozzle exit where the gas stream velocity is relatively low and the losses accompanying the turning of the stream are consequently low. The cascade of turning vanes provides for the abrupt turning of the stream. Vanes are shaped to leave a nozzle exit which comprises exit passages in which the areas decrease rapidly toward the exit. Therefore, the gas velocity increases rapidly with an accompanying decrease in pressure at the regions of the turn, reducing the tendency for separation.

Variable area and direction changing propulsive nozzle (Patent No. 2,802,333). Natham C. Price, Hollywood, and Willis M. Hawkins Jr., North Hollywood, Calif., assignors to Lockheed Aircraft Corp.

government contract awards

Convair Orders $8.9 Million Jet Engine Thrust Reversers

Convair Div. of General Dynamics has assigned an $8,900,000 order for jet engine thrust reversers to General Electric Co. This is in addition to a previous $20,000,000 contract for GE J-79 engines to power Convair's jetliner, the 880. The thrust reversers will be used on these engines as a braking force in bringing the plane to a halt after it touches down on the runway.

IRBM Job to General Motors

The A/C Spark Plug Div. of General Motors received a $38-million contact for research, development and production of inertial guidance systems used by the Thor intermediate-range ballistic missile.

Grand Central Rocket Co. Orders Instrumentation Van

Grand Central Rocket Co. has let a contract to Era Engineering, Inc., Santa Monica, Calif., for the assembly and checkout of an instrumentation van which it will use at one of its remote static rocket motor firing areas. The van will house electronic recording and pick-up instruments and a master fire control panel developed by Era, and will act as a central communication center for the test area.

Missile for B-52

Air Force has let a high priority contract to North American Aviation for an air-to-surface missile for the B-52 bomber. Amount of the contract was not released. Six weeks of "intense and comprehensive analysis and evaluation" of proposals from a dozen companies preceded the award, the Air Force said. NAA was recently hard hit by AF decision to discontinue work on the company's intercontinental ramjet missile, Navaho.

Consolidated Electrodynamics Nets $800,000 in Contracts

Consolidated Electrodynamics has received two contracts totaling $800,000 for magnetic-tape recorder-reproducer equipment called "DataTape."

The first award for $720,000 was made by Melpar, Inc., a subsidiary of Westinghouse Brake Co., to the Datalab Div. of Consolidated Electrodynamics.

The second order was from the Air Research Development Command, Baltimore, Md., for $80,000 additional equipment similar to the instrumentation previously supplied for the testing of intercontinental ballistic missiles at Patrick AFB, Fla. The equipment records telemetered data, such as temperatures, pressures and thrust, and plays it back for analysis and interpretation.

Navy Procuring Grumman Transonic Fighter-Trainer

The Navy disclosed that it will purchase Grumman Aircraft's transonic fighter-trainer, the F9F-8T Cougar, to fulfill fleet requirements for that type aircraft. The amount of the contract and airplanes was not revealed. However, a Grumman spokesman said the contract would probably be a substantial one.

Contracts Pour In

Precision Equipment Co. has announced receipt of contracts from the Air Force, Navy and prime contractors for liquid rocket propellant support equipment.

$11 Million Award To Marquardt

The Air Materiel Command has awarded an $11,719,693 contract to Marquardt Aircraft Co. for ramjet engines.

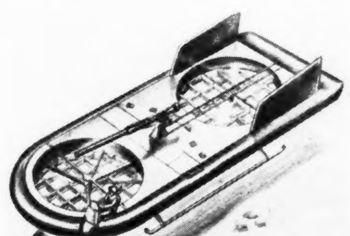
AF Orders Minute Cameras To Track Missile Flight

Diminutive motion picture cameras that can be installed in aircraft and pilotless drones to record missile data and flight positions have been ordered from Gordon Enterprises, North Hollywood, by the Air Materiel Command. The amount of the contract is said to exceed $100,000.

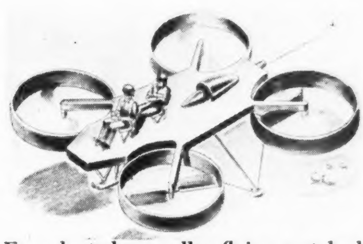
Servomechanisms Receives $1.9 Million Hughes Contract

Hughes Aircraft Co. has let a $1,894,000 production contract to Servo-

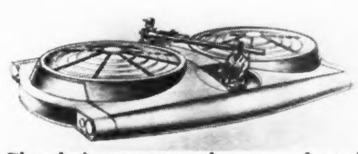
Army Wants 'Aerial Jeep'



Piasecki's version of prototype aerial jeep employs two ducted propellers.



Four-ducted propeller flying test bed was proposed by Aerophysics.



Chrysler's prototype has two ducted propellers, places men side by side.

Contracts totalling $1,702,000 were recently awarded by the Army to three different corporations—Piasecki Aircraft, Aerophysics Development and Chrysler—for research and development of an "aerial jeep." The Army wants a general utility vehicle that can travel 50 mph, stay in the air for several hours, and carry 1000 lb of weapons or equipment. If the venture is successful, the new concept could lead to the eventual development of an "aerial truck."

Recent developments in direct lift devices using the ducted fan, improved powerplant designs, and advances in vertical take-off research, contributed to the Army's decision to go ahead with plans for the new-type aerial vehicles.

mechanisms, Inc., for a new barometric altitude controller employed for fixed altitude flying. The system measures aircraft and missile altitude deviations as small as $2^1/_2$ ft at sea level, and can control, with extreme precision, altitudes anywhere within the range of 1000 ft below sea level to several miles above sea level. In flight operations it will provide an altitude hold which supplies a signal to an autopilot for high accuracy constant barometric altitude.

SYNOPSIS OF AWARDS AND CONTRACTS

The following synopsis of government contract awards lists formerly advertised and negotiated unclassified contracts in excess of $25,000 for each Air Force, Army and Navy contracting office:

AIR FORCE

AF Cambridge Research Center, ARDC, Laurence G. Hanscom Field, Bedford, Mass.

Design and development of balloon carrier system, $245,000, **Tufts College**, Medford, Mass.

Research and development directed toward the flight of two biaxial pointing controls in Aerobee rockets, $49,813, **Ball Brothers Research Corp.**, Box 191, Boulder, Colo.

Commander, HQ, AMC, Wright-Patterson AFB, Ohio.

Tank assemblies for F-100 aircraft, $2,046,073. **The O. A. Sutton Corp.**, 1812 W. 2nd St., Wichita 1, Kans.

San Antonio R&D Procurement Office, ARDC, PO Box 63, Lackland AFB, San Antonio, Tex.

Research and development of the use of remote manipulators in maintenance of nuclear-powered aircraft, $99,222, **Borg-Warner Corp.**, Research Center, Des Plaines, Ill.

ARMY

Corps of Engineers, U. S. Army, Omaha Dist., 1709 Jackson St., Omaha 2, Nebr.

Construction of Nike Electrical Distribution, West Site, Ellsworth AFB, S. D., $61,867, **Flora Construction Co.**, 765 Gilpin St., Denver, Colo.

District Engineer, U. S. Army Engineer Dist., Albuquerque, PO Box 1538, Albuquerque, N. Mex.

Construction of prototype Nike launcher, White Sands Proving Ground, N. Mex., $83,700, **Robert E. McKee General Contractor, Inc.**, 1918 Texas St., El Paso, Tex.

Philadelphia Ordnance Dist., 128 N. Broad St., Philadelphia, Pa.

Nine hundred man-months of installation, repairing, modifying and developing electronic and related equipment for guided missile program, $686,594, **RCA Service Co., Inc.**, Camden 8, N. J.

Nike spare parts and components, $60,240, **Western Electric Co.**, Burlington, N. C.

Picatinny Arsenal, Dover, N. J.

Production engineering of JATO, $87,402, **Chrysler Corp., Defense Operations Div.**, PO Box 1687, Detroit 31, Mich.

Purchasing and Contracting Office, U. S. Army, Engineer R&D Laboratories, Corps of Engineers, Fort Belvoir, Va.

Turbo-expander, $45,193, **Fairchild Engine & Airplane Corp.**, Stratos Div., Bay Shore, L. I., N. Y.

Studies and report on mobile liquid oxygen plant, $59,430, **Hydrocarbon Research, Inc.**, 11 S. Broadway, N. Y., N. Y.

Redstone Arsenal, Huntsville, Ala.

Hydrogen peroxide, 90% CP Grade, deposit on 250-lb aluminum drums, $41,850, **E. I. Du Pont de Nemours & Co., Inc.**, Wilmington, Del.

Hydrogen peroxide, 90%, 76% CP Grade, deposit on 250-lb aluminum drums, $59,718, **E. I. Du Pont de Nemours & Co., Inc.**, Wilmington, Del.

Liquid oxygen, $49,500, **Linde Air Products Co.**, 2900 Cahaba Road, Birmingham, Ala.

U. S. Army Ordnance Dist., Los Angeles, 55 S. Grand Ave., Pasadena, Calif.

Missile technical representative services, $1,670,064, **Douglas Aircraft Co.**, 3000 Ocean Park Blvd., Santa Monica, Calif.

U. S. Army Signal Corps, Washington 25, D. C.

Research and development of high speed drones, $12,000,000, **Fairchild Aircraft Div., Fairchild Engine and Airplane Corp.**, Hagerstown, Md.

Development and production of a new service test model of combat surveillance systems, all-weather drones, $4,700,000, **Republic Aviation Corp.**, Conklin St., Farmingdale, L. I.

NAVY

District Public Works Officer, Sixth Naval Dist., Bldg. 13, U. S. Naval Base, Charleston, S. C.

Additional base facilities for AF missile test center offshore facilities at San Salvador Auxiliary AFB, San Salvador Is., Bahamas, $148,800, **Nat G. Harrison Overseas Corp.**, 5137 NE 2nd Ave., Miami, Fla.

District Public Works Office, Ninth Naval Dist., Bldg. 1-A, Great Lakes, Ill.

Furnishing one wagon mounted crane for Cape Canaveral, Fla., $107,915, **Industrial Brownhoist Corp.**, 135 Washington Ave., Bay City, Mich.

Next Time, Perhaps

On the morning of March 29, seconds after launching, Japan's first guided missile, the TMB-O (above), crashed. A second test firing also ended in failure, and Japan's guided missile program ground to a temporary halt as further firings were canceled.

Part of a long-range plan for modern armaments, the TMB-O is intended as a precursor of American-type guided missiles in the Sparrow air-to-air and Nike ground-to-air categories which Japan hopes to produce by 1960. The TMB-O is an outgrowth of guided missile research begun in 1954 by the Defense Agency's Technical Research Institute (see Jet Propulsion, Oct. 1956, p. 893). The test missiles were manufactured by Shin Mitsubishi Heavy Industries; engines were supplied by Fuji Precision Machinery Co.; and the radio-controlled command guidance system by Mitsubishi Electric Co.

The TMB-O is about 4.3 ft long and spans slightly over 3 ft. Wings are swept back 41.8 deg. The missile is fired from a 52-ft launcher and has a range of almost 2 miles. Normally, the test vehicles are programmed for parachute recovery.

Vanguard Control System

(CONTINUED FROM PAGE 36)

second and third stages. A coasting time computer determines the time at which the third stage is to be separated and fired.

As a form of back-up guidance, the vehicle is tracked after second-stage burnout; and, from trajectory information, the proper firing time for the third stage can be found on a ground-based computer. Then, if desired, the third stage can be fired from the ground by sending a command to the vehicle.

This, briefly, is how the earth's first artificial satellite is expected to reach its orbit. A fairly involved bit of work, Vanguard's control system represents the collective work of a number of top scientists and engineers. The system has already undergone extensive ground testing. Numerous simulation studies have also been run. And now the system is going through an extensive flight-testing phase.

But the big test, as always, will come when the final firing button is pushed.

Missile Market

(CONTINUED FROM PAGE 50)

tracted) over the next 3–4 years.

Over 95 per cent of the company's sales are to the Government, but Aerojet is fast developing products that also have application in the commercial field, such as jet components that can be adapted to commercial aircraft and the company's new portable nuclear reactor. In 1952 the company had sales of $30 million which procured a net of about $1.00 a share on the present capitalization. Its growth in the past five years leaves no doubt as to management's ability to maintain its top position in the missile-rocket field.

The company recently raised $7.5 million through a private placement of common stock which will help to finance its future growth, including expansion of facilities in the current year amounting to $5.7 million. Additional financing can be expected over the coming years. Although dividends cannot be looked for in the near future, and the stock is not cheap on a statistical basis, commitments in the company's securities should provide attractive capital gains over the long pull. The stock is expected to split at least 10-for-1 within a year.

Marquardt Aircraft—Traded over the counter, approximate price, $30. Reported for 24 weeks ending June 16, 1957: Sales of $17 million vs. $8 million; net per share $0.64 vs. $0.57; 550,456 shares of common outstanding; 25.8 per cent owned by Olin Mathieson, 19.7 per cent by Laurance Rockefeller, 11.8 per cent by officers and directors.

Although it can be considered a one-product company, there is little doubt as to the success and future growth potential of Marquardt's product—the ramjet engine. Sales so far this year are more than double the 1956 volume, the backlog in February of this year exceeded $55 million (exclusive of Government facilities contracts). The future is further assured by the Air Force's decision to go into quantity production with the Boeing Bomarc. With the award of a $139-million contract to Boeing, the Government automatically gave the nod to the two air-breathing ramjet engines produced by Marquardt, which go into each Bomarc missile.

Started in 1944 with $1000 and an idea by Roy E. Marquardt and subsequently helped by the "smart" money of General Tire (which at one time owned 85 per cent of the stock and later sold out to Laurance Rockefeller who in turn split his holdings with Olin Mathieson), the company has come far with its single product, even though it has not been an easy road. Sales are still to a large extent in development programs, not production, and at the outset there was no guarantee that the company would be permitted to produce the engine it had spent ten years developing. Even this year, Marquardt expects 80–85 per cent of its sales to come from research and development.

Production for the Bomarc missile will help bring better balance to the operation. Although the company is developing other products now, 83 per cent of today's sales are still in ramjets. The company's facilities have kept apace with sales. The latest project is a $20 million test facility west of Ogden, Utah, built with Air Force funds. This new facility, close to Marquardt's own $5-million production plant, opened in June of this year. The company's securities do not seem overpriced at recent levels for the patient, capital gains minded investor.

Next month: Reaction Motors and Ramo-Wooldridge.

Market Letter Gleanings

Bendix Aviation—"Looks attractive as a purchase for long term." (Moody's)

The Martin Co.—"With procurement emphasis trending toward missiles, Martin is in a good position. Its stock . . . should be held." (United Business Service)

American Bosch Arma—"Would continue to hold this equity for long-term capital gains." (Fitch)

Emerson Electric—"Near-term sales and earnings prospects . . . are favorable, and the company's extensive cost reduction program will be beneficial. Holdings in the stock should be fully retained." (Standard & Poor's)

Lockheed Aircraft—The company's 3.75 per cent subordinated convertible debentures, yielding about 5.5 per cent on their recent price are highly recommended for purchase at the present time by Reynolds & Co.

Aircraft Stocks—"The pendulum of investor evaluation historically has swung to extremes in either direction. As the outlook is not disheartening for all companies, currently it appears that an unduly pessimistic attitude is being taken. Selected issues, such as Douglas, Martin, Northrop and United, seem to have recovery possibilities." (Standard & Poor's)

new equipment and processes

EQUIPMENT

Magnetic Contact Relay: The new ruggedized and sealed Model 281 10-microampere magnetic contact relay is built to MIL-ORD OD-9678 and will withstand more than 500 g and vibration of 5 to 55 cps at 0.060-in. amplitude. Insulation resistance exceeds 1000 megohms. Either ac or dc may be pulled through the contacts. It measures approximately $2 \times 1^3/_4 \times 1^1/_2$ in. Although the unit is sealed, the clear plastic case permits observation of much of the movement. Assembly Products, Inc., Chesterland, Ohio.

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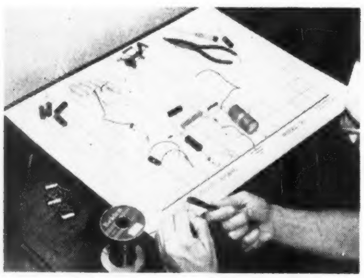
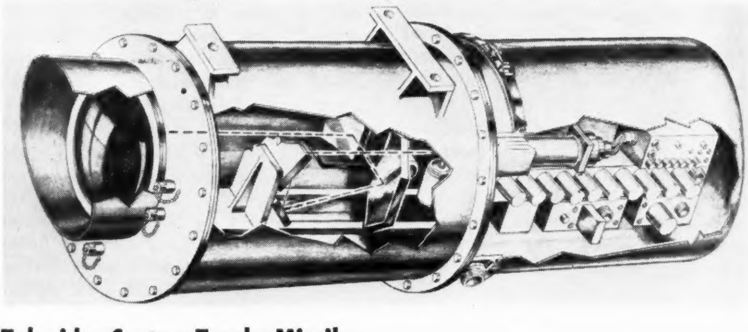
Jet Engine Starter: A hydraulic ground-mobile jet engine starter has been announced by Vickers. Demonstrations have been made on the Allison 501-D4 turboprop engine (average starting time to idle speed 40 sec) and the J-57 engine (time to starter cut-out speed 31 sec). The prime mover drives a variable delivery pressure compensated pump with an over-all efficiency of 92%. Servo controls on the prime mover, throttle and pump pressure compensator assure optimum speed and power delivery to the starting motor mounted on the engine pad throughout the starting cycle. Vickers, Inc., Detroit 32, Mich.



Conductive Cells: A breadboarding technique based on a concept of making solderless electrical connections promises to simplify the mechanics of electronic circuit development. The assembly technique is based on the use of small cells or "pockets" of conductive material. Component leads, or the ends of jumper wires, are electrically connected simply by inserting them into the conductive cells. Individual components may be replaced or reassembled without damaging leads or loosening contacts. Van-Dee Products, 300 Ocean Ave., Laguna Beach, Calif.



Televideo System Tracks Missiles

Employing a 37-in. telescope lens system for its camera tube, the 600-line high resolution Canoga Televideo System is used for observation applications such as missile engine and aircraft testing, and missile tracking.

Radiant Heater: Up to 48 kw/ft^2 can be converted to heat and "poured" into aircraft and missile test specimens with a new high-output radiant heating reflector. Each reflector unit measures 6×12 in. and carries eight heat lamps rated at 1 kw, each capable of 300 per cent overload for short periods. Typical uses have been in structural test facilities where the units and associated electronic controllers simulate the transient heating effects of supersonic flight. A heat input rate schedule is first calculated for a particular flight path, and these data are fed to computers which solve heat transfer equations and regulate power applied to the heaters. Research, Inc., 115 N. Buchanan, Hopkins, Minn.

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Linear-Stroke Solenoid: Designed for applications in instrumentation and missile control, a new Maurer small, lightweight shock-resistant solenoid meets Air Force environmental requirements. The solenoid is made of steel finished in cadmium plate. Operating on 28 v, the plunger stroke bridges a gap of 0.080 in. at 24 v and exerts a minimum pull of 6 oz. Dimensions: $0.672 \times 0.622 \times 0.622$ in. Weight is less than 1 oz. J. A. Maurer, Inc., 37-01 31st St., Long Island City, N. Y.

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Miniature Motor: Designed for missile application, Model P2P11A, a miniature 12 to 16 v dc motor is capable of operating in dry nitrogen gas at 30 mm of mercury pressure absolute for 200 hours. The motor is rated 1/100 hp at 10,000 rpm. It draws 2.5 amp at full load and 0.7 amp no load. Develops 1 oz in. of torque in continuous duty or 1.85 oz in. intermittent service. Diameter is 1.127 in., length, 1.750 in. Western Gear Corp., P. O. Box 182, Lynwood, Calif.

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Relief Valve: A line of relief valves for airborne applications is available for pressures from 1 to 6000 psi. One of these, the MC 1613 valve, is designed for air or nitrogen and conforms to military specifications. Features include compactness, accurate setting and low leakage. Ambient temperature range −65 to +250 F. Maximum operating pressure 3800 psi. Port connections are for $^1/_4$ in. tubing. M. C. Manufacturing Co., Lake Orion, Mich.

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Swivel Fittings: Dumont fully rotating swivel fittings are manufactured in various tube sizes and end fittings for liquid or gas service in missile, aircraft and industrial hydraulic applications up to 3000 psi pressure and in temperature range −65 to +275 F. Available in aluminum alloy or stainless steel. They have low torque values under high side loading, and are made with high energizing, low friction, positive, slipper-type seals. Dumont Aviation Associates, 1401 Freeman Ave., Long Beach 4, Calif.

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Pressure Operated Valves: Now in production, a series of lightweight, pressure-operated shut-off valves designed for extreme low temperature and high pressure applications, in line sizes from $^1/_4$ to 3 in., has the following features: Floating ball-seat valve with self-wiping and self-lapping action; axial hole-in-a-ball design pro-

viding unobstructed flow path for minimum pressure drop at all rates of flow; bubble-tight flow control thru a temperature range of −320 to +200 F, at pressures up to 3000 psi. Gases and liquids handled include most of those used in hydraulic, fuel and pneumatic systems. Hydromatics, Inc., Cedar Grove, N. J.

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Laboratory Mixer: The Z-Blade Laboratory Mixer offers good mixing efficiency with batches as small as 5 cu in. It has a 1-pint capacity and is demountable for ease of cleaning. Corrosion- and abrasion-resistant materials are used in all parts in contact with the material being mixed. Aluminum is used in other parts so that the mixer bowl may be removed from the unit and the contents poured out by hand when mixing is completed. The mixer was developed to meet an unusually difficult mixing requirement in rocket propellant development projects. Atlantic Research Corp., Alexandria, Va.

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High-Vacuum Pump: Evapor-Ion Pump, Type EI-2000A, provides an electronic method for producing high vacuum without the use of organic pump fluids. It creates a "dry" vacuum in the range from 10^{-4} to 10^{-8} mm Hg. Active gases are pumped by the gettering action of evaporated titanium wire, inert gases are pumped by ionizing and burying them under a layer of titanium. Pumping speed 1900 liters per sec for nitrogen, 1000 liters per sec for oxygen and 3000 liters per sec for hydrogen. It also pumps many other gases, including water vapor, at high speed. Rochester Div., Consolidated Electrodynamics Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.

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Hose for Chemicals: A hose capable of handling concentrated hydrogen peroxide has been developed. It is made of a fabric-reinforced silicone rubber and is available in sizes up to 6 in. ID, and in lengths up to 50 ft. The components of the hose are not affected by, and do not cause decomposition of, the chemical. Hewitt-Robins Inc., Stamford, Conn.

MATERIALS

Adhesive: Narmtape XP-108, a new high performance adhesive, was designed specifically to eliminate the need for core priming in sandwich component fabrication. It also provides materially improved peel strength. XP-108 consists of a nylon carrier impregnated with a modified phenolic resin and overcoated on one surface with a highly mobile filleting resin. The addition of resin eliminates a time-consuming step in the fabrication of aircraft and missile structures of bonded sandwich design. Narmco Resins & Coatings Co., 600 Victoria St., Costa Mesa, Calif.

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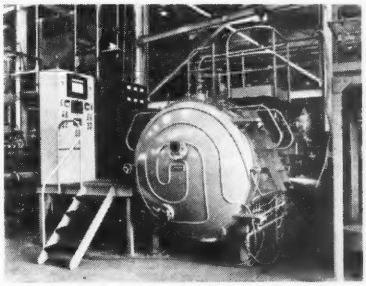

Furnace to Explore Tough Metals: Precise industrial engineering investigations on titanium, other reactive metals, and new guided missile materials for various applications will be carried out by Watertown Arsenal, Watertown, Mass., with the help of this Stokes 500-lb-capacity vacuum melting furnace.

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Borosilicate Glass: A hard glass, KG-33, will serve as a new source of supply for laboratory and research requirements. KG-33 possesses the following physical properties: Strain point, 515 C; annealing point, 555 C; softening point, 820 C; linear coefficient of expansion 32.5 × 10-7 cm/cm/C (0.300 C); density, 2.23; refractive index—sodium (D line), 1.47; visible light transmission, 2 mm thickness, 92%. Kimble Glass Co., subsidiary of Owens-Illinois Glass Co., Toledo, Ohio.

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Rocket Oxidants: Production has begun on two new products—lithium perchlorate and lithium nitrate for use in rockets and missiles. The two chemicals are both oxidants to provide oxygen for solid propellants. As oxidants, they also may be used in flares and other pyrotechnics. Both of the lithium compounds have a high oxygen content—about 60% in lithium perchlorate and nearly 70% in lithium nitrate. American Potash & Chemical Corp., Henderson, Nev.

PROCESSES

Thermocompression Bond: A breakthrough in the technique of attaching leads to semiconductor devices has been achieved. A combination of heat and pressure is employed to provide a bond between various soft metals and single crystal semiconductor surfaces. Called thermocompression bonding, this technique provides a bond that is stronger than the lead itself. Temperatures and pressures required are not high enough to affect the electrical properties of the semiconductor material. Bell Telephone Laboratories, 463 West St., New York 14, N. Y.

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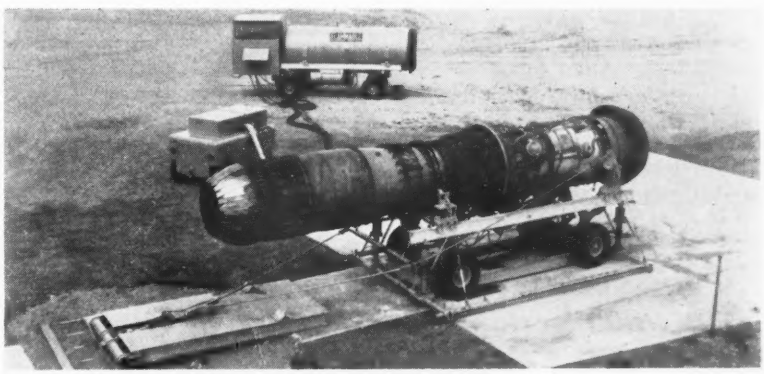
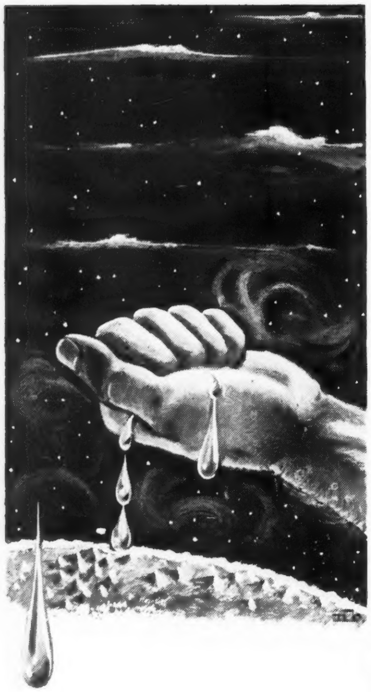
Ceramic Coatings: An urgent need has arisen for surface protection of metals used in temperature ranges above 1000 F. Because of the refractory and insulating properties of new ceramic coatings, these structural aluminum alloys can withstand prolonged heat at 1300 to 1350 F without collapsing. Tests were performed on 0.040 in. aluminum sheet with a coating of 0.0015 in. thickness. Subjected to a flame impingement test for 120 min at a flame temperature of 2200 F, the specimen was not damaged. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.



Mobile Test Units

Air Logistics Corp.'s new jet engine test system consists of two specially designed units plus a standard gas turbine cart. The first unit carries a removable instrument and control booth and fuel tank. The second unit is equipped for engine run-up, and the cart is used for starting the engine.



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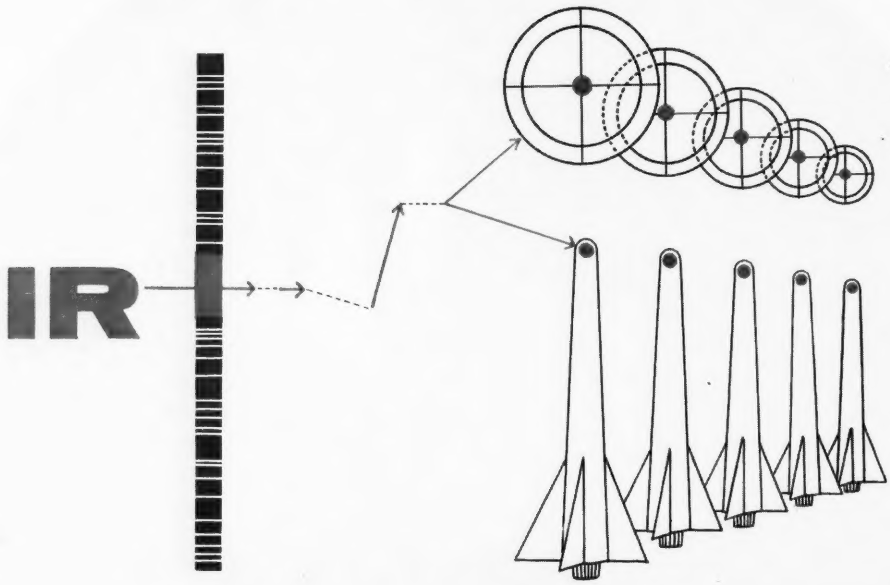
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